Energy Research and Development Division
FINAL PROJECT REPORT

INTEGRATING BUILDING COMMISSIONING INTO STATE BUILDING CONSTRUCTION

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Prepared by: Architectural Energy Corporation

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The project team acknowledges the support of the California Energy Commission PIER program, the California Department of General Services, and others in the engineering & commissioning communities that directly or indirectly have contributed to the information in this report.

This work could not have been completed without contributions from many people, especially Daniel Burgoyne, who led the effort within DGS. Thanks also to DGS staff who have contributed throughout the process including Tim Bow, Dan Burgoyne, Dennis Corelis, Bob Courtnier, Jesus Cuevas, Lewis Dean, Steve Durham, Diane Elliot, John Golemon, Jeff Henninger, Wes Hubbart, Rich Langley, Fred Luzzi , Donna Mangine, Roy McBrayer, Linda McMullen, Richard Myren, Charlie Nelson, Howard Sacks, Annette Salazar, Burton Shanoff, Gary Sills, and Lorrie Uribe.

Thanks also go to the Program Advisory Committee, consisting of many of the Department of General Services staff members listed above, as well as the following outside experts: Kenneth Gillespie, Evan Mills, Chuck Shinneman, and Lowell Shields.

This project is funded by the California Energy Commission's Public Interest Energy Research program, and overseen by Norman Bourassa, Martha Brook, and Daryl Mills.

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The Energy Research and Development Division strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

Energy Research and Development Division funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Program Final Report - Integrating Building Commissioning into State Building Construction is an interim report prepared by Architectural Energy Corporation under the Integrating Building Commissioning into State Building Construction Program (contract number 500-04-016) that is managed by Architectural Energy Corporation. The information from this project contributes to Energy Research and Development Division's Buildings End-Use Energy Efficiency Program.

For more information about the Energy Research and Development Division, please visit the Energy Commission's website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.

ABSTRACT

The goal of this project was to improve the realization and persistence of proper operation and resource efficiency in new California buildings or major renovations by developing a comprehensive commissioning framework, resulting in lower energy use, lower operation and maintenance costs for California, longer building life, and greater worker productivity and user comfort. The project was intended to benefit California's Department of General Services, other state agencies, and the general public. This report was developed from the material detailed in the Task 2 through Task 7 reports of this project on incorporating an in-house commissioning framework into the Department of General Services capital outlay projects. Task 1 was the overall management task for the project, including development of this report. The project tasks included: 1) exploring the feasibility of the project goals; 2) assessing the cost benefits of an integrated commissioning framework to California; 3) developing a preliminary in-house commissioning framework for California's Department of General Services; 4) exploring the commissioning framework in the context of a pilot program with a state construction project; 5) revising the in-house commissioning framework based on review by a project advisory committee and lessons learned from the pilot construction project; and 6) developing training material on the commissioning process for communication to the Department of General Services, other state agencies, and the general public. The overall project was successful, and the project advisory committee recommended that the proposed in-house commissioning framework be considered for implementation in a step-wise, phased manner. The training material on the commissioning process for outreach to other state agencies and the general public was suitable for incorporating into web-based instruction, other electronic educational media, classroom presentation, or a combination of presentational modalities.

Key words: Department of General Services, commissioning benefits, integrated commissioning, commissioning framework, training, State-wide communication.

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Integrating Building Commissioning into State Building Construction

Appendix A: Task 2 Report - Preliminary Assessment of Feasible Options to Provide Commissioning Services to DGS

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Arnold Schwarzenegger, *Governor*

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Integrating Building Commissioning into State Building Construction

Assessment of Options for Incorporating Commissioning Services to DGS Building Projects

CONSULTANT REPORT

Prepared For:
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Arnold Schwarzenegger, *Governor*

Subtask 2.0 Deliverable

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by binging environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Assessment of Options for Incorporating Commissioning Services to DGS Building Projects Report is an interim report prepared by Architectural Energy Corporation under the Integrating Building Commissioning into State Building Construction Program (contract number 500-04-016) that is managed by Architectural Energy Corporation. The information from this project contributes to PIER's Buildings End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/pier or contact the Energy Commission at 916-654-5164.

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Abstract

The goal of the Integrating Building Commissioning into State Building Construction Program is to improve the realization and persistence of proper operation and resource efficiency in new State buildings, resulting in lower energy use, lower operation and maintenance costs to the State, longer building life, as well as greater worker productivity and user comfort.

The overall objective of this program is to establish and implement quality and consistent commissioning services by the California Department of General Services (DGS) during their building planning, design, construction & operation processes, resulting in a lower overall cost of delivering service to the taxpayer. This objective will be achieved by collaborating with key staff and management within the DGS to develop procedures, protocols, and specifications for commissioning new state buildings.

Today's buildings have complex equipment and systems and frequently do not operate optimally or as efficiently as intended. Total building commissioning is a process for assuring that the total performance of new buildings and their systems work as intended. Following the signing of California Executive Order S-20-04, all state buildings larger than 10,000 square feet (ft^2) must achieve USGBC LEED® (Leadership in Energy and Environmental Design) certification to the Silver level or better, and some level of commissioning is required.

This report assesses options for incorporating in-house commissioning (Commissioning) in the California Department of General Services (DGS) new construction delivery process. The Real Estate Services Division (RESD) of DGS provides services to all State agencies, including the acquisition of new buildings for many agencies. Currently, the vast majority of new buildings are commissioned by third-party professionals.

There are many alternative paths for providing commissioning services on DGS projects, and three approaches are discussed in this report: 1) DGS staff serves as in-house commissioning authorities, with supplementary assistance from third-party contractors in special cases; 2) In-house regional commissioning managers would be responsible for overseeing the work of third-party commissioning contractors; 3) DGS would continue to use third-party contractors to provide commissioning services, with DGS project directors overseeing the work of the commissioning contractors. Some combination of all three paths would be a viable option.

There are significant potential benefits to developing in-house DGS commissioning expertise. *Perhaps the greatest benefits are retained knowledge, consistent application of methods, and better access to that expertise throughout the life of the building from design to construction to operation and maintenance.* Disadvantages to in-house Commissioning stem primarily from uneven workload, turnover and job promotion, and the relatively high hourly billing rate that DGS staff charges to projects.

1.0 Executive Summary

This report assesses options for incorporating commissioning (Commissioning) in the California Department of General Services (DGS) new construction delivery process. The Real Estate Services Division (RESD) of DGS provides services to all State agencies, including the acquisition of new buildings for many agencies. The groups within RESD involved in this effort are described in Section 5.0 of this report.

A 2006 snapshot of the portfolio of DGS new construction projects for which commissioning appears to be appropriate includes 29 projects totaling 2.9 million square feet. The projects range in size from about 3,000 to 1.4 million square feet. Project types include offices, mixed use, healthcare, kitchens, dormitories, and other types.

Following the signing of California Executive Order S-20-04, all State buildings larger than 10,000 square feet (ft^2) must achieve USGBC LEED® (Leadership in Energy and Environmental Design) certification, and some level of commissioning is required. Currently, most of the commissioning is being performed by third-party commissioning authorities, not DGS personnel.

In 2006, the DGS developed a procedure (Commissioning Toolkit for Small Projects) for performing in-house commissioning of projects smaller than 10,000 ft^2, which do no require LEED certification but are expected to follow LEED criteria. The approach relies on personnel from two sections within the Professional Services Branch (PSB): 1) engineers from the Design Services Section (DSS) to cover design-phase tasks, and 2) inspectors from the Construction Services Section (CSS) to perform construction-phase tasks. Tasks 4 & 6 will explore the use of the Commissioning Toolkit within the Building Project Management Branch (BPM) for special repairs and related needs.

Other institutions around the country have developed approaches to in-house commissioning, and their experiences are briefly described in Section 10.0. The University of California at Davis is one example of a State organization that commissions most of its projects with in-house staff.

The scope of commissioning services, and the system types covered by a commissioning process, vary from a minimum scope required by LEED to a full scope corresponding to "total building" commissioning. The LEED scope covers HVAC, lighting, water heating, and renewable energy systems and associated controls. A total building commissioning process adds systems such as building envelope, plumbing, security, electrical, telecommunications, irrigation, and acoustics. These commissioning activities are discussed in Section 11.0.

Successful commissioning authorities (Commissioning As) come to the role from a number of different backgrounds. Regardless of their background, there are several characteristics that are especially valuable, such as fundamental knowledge of how building systems and their controls function, understanding of both design and construction processes, ability to manage complex long-term projects, sufficient

experience to earn respect from both the design and the construction teams, and personal qualities that enable one to be a problem solver in a "politically charged" environment.

Information required to develop a "duty statement" for an in-house commissioning authority is included in Section 12.1, including essential functions, marginal functions, knowledge and abilities, desirable qualifications, interpersonal skills, additional desirable qualifications, and work environment.

Typical salaries for commissioning authorities in the private sector range between $85,000 and $120,000, with some potentially as high as $150,000 with managerial responsibilities. DGS classifications that appear to match up fairly well with industry commissioning authorities salaries include Construction Supervisor II ($81,444 to $99,000), Senior Mechanical Engineer ($88,452 to $107,460) and Construction Supervisor III ($97,164 to $118,104). See Section 12.2 for more information.

Analysis undertaken for this report indicates that five in-house commissioning authorities would be required to handle the DGS project workload, based on the snapshot of 29 projects described above. This estimate is based on detailed time estimates for several typical project types, which are then extrapolated to the total set of projects. This method estimates close to 7,800 hours per year of commissioning project time. Assuming that each staff member has 1,600 hours per year available, then five staff members are needed. If one or more junior engineer support staff is provided, then four commissioning authorities could likely handle the workload. See Section 13.0 for more information.

There are many alternative paths for providing commissioning services on DGS projects, and three approaches are discussed in this report. Advantages and disadvantages of each approach are discussed in Section 14.0.

1. **In-house commissioning authorities.** DGS staff serves as commissioning authority (CommissioningA) for the majority of projects, with supplementary assistance from third-party contractors in special cases.
2. **In-house commissioning project managers**. Regional commissioning managers would be responsible for overseeing the work of third-party commissioning contractors. These managers would develop an in-depth understanding of the commissioning process and would also develop relationships with regional commissioning providers. It is likely that two regional managers would be able to handle the workload.
3. **Third-party contractor commissioning authorities**. DGS would continue to use third-party contractors to provide commissioning services. DGS project directors would oversee the work of the commissioning contractors.

There are significant potential benefits to developing in-house DGS commissioning expertise. Perhaps the greatest benefits are retained knowledge, consistent application of methods, and better access to that expertise throughout the life of the building from

design to operation and maintenance. These benefits will be explored in much greater detail in Tasks 4 & 6 (the preliminary and revised plans for integrating Commissioning into DGS capital outlay projects). Task 5, the piloting of Commissioning services on a new state building project (the Caltrans facility in Marysville CA), will serve to inform Task 6. Task 7 will develop and deliver training protocols based on information gathered, and lessons learned, in Tasks 4-6.

Probably the most significant disadvantages to using in-house commissioning authorities are the ability to respond quickly to changes in workload (i.e. quickly adding or subtracting staff) and the relatively high hourly billing rate that DGS staff charges to projects.

A solution to the issue of varying workload is to rely on third-party commissioning contractors to handle peaks in workload when in-house commissioning authorities are busy. A hybrid of the three approaches described above may be the appropriate path.

2.0 Introduction

The goal of this report is to describe the assessment of the options for incorporating commissioning services into the new construction building delivery process. The State of California Department of General Services (DGS) and the Department of Finance (DOF) intend to incorporate commissioning services into the planning, design review, construction management, and operation and maintenance (O&M) services already provided by the DGS during new construction projects.

This report provides information to assist DGS in developing a budget change proposal, if appropriate, to develop commissioning staff capability. This information includes the skills required of commissioning providers, the number of staff required to serve the DGS project load, and the costs to provide commissioning services for DGS projects.

Over the last several years, a group of DGS staff from several branches have served as the Commissioning Implementation Team. These individuals have played a key role in guiding the development of this report.

Additional work following this assessment of commissioning delivery options will include development of an implementation plan that includes commissioning policies and procedures.

3.0 Background

Today's buildings have complicated equipment and sophisticated and complex building systems. Often new buildings do not operate optimally or as efficiently as intended. Total building commissioning is a process for accomplishing, demonstrating, and documenting that the holistic performance of the total building and its systems work as intended. A building's performance is greatly enhanced by commissioning of all building systems including electrical, mechanical, lighting, exterior envelope, landscaping, storm water control, plumbing, and acoustics.

A commissioning process can improve the realization and persistence of proper operation and resource efficiency in new State buildings, resulting in lower energy use, lower operation and maintenance costs to the State, longer building life, and greater worker productivity and user comfort.

The State of California Department of General Services (DGS) is responsible for the procurement and construction of State real property. For new construction projects, the State's current capital outlay process does not adequately document, integrate, and track the owner's and client's project requirements throughout the design and construction process. It does not adequately ensure that buildings perform as desired or as designed, or that operation and maintenance staff members are adequately trained or prepared to operate the facility into the future. These conditions result in less than optimal energy usage and decreased building systems life, increased costs to the State, and reduced productivity and comfort of the building occupants.

Recent DGS and State activities related to new-building commissioning include the following:

- In 2002/2003, DGS staff worked with an outside consultant to investigate commissioning approaches, and the result of that work is documented in the report titled, *Total Building Commissioning Process Strategic Plan FY 2002-2003.*
- In 2002/2003, the Division of the State Architect worked with a consultant to develop a document titled *Adopting the Commissioning Process for the Successful Procurement of Schools*, which was "intended to be used by school districts, programmers, design professionals, contractors, operations and maintenance personnel, and Commissioning Authorities to understand the Commissioning Process and their role in it."
- In 2004, the Governor Schwarzenegger signed Executive Order S-20-04. The associated Green Building Action Plan includes the requirement that all State buildings larger than 10,000 ft^2 achieve LEED certification at a level of Silver or better. The affect of this policy is that a minimum level of commissioning is required for each of those projects.
- In 2005, the California Energy Commission's Public Interest Energy Research (PIER) program funded the work that has resulted in this report and will support development of an implementation plan.

- In 2006, the California Commissioning Collaborative published a Commissioning guideline for California buildings.
- In 2006 and 2007, with assistance from the PIER-funded consultant, the DGS developed a toolkit for commissioning of small buildings. http://www.green.ca.gov/CommissioningToolKit.

4.0 Overview

The Real Estate Services Division (RESD) within DGS provides comprehensive real estate services to all state agencies. Comprised of five operational branches, RESD conducts asset planning, property sales and acquisition, project management, architectural and engineering services, leasing and planning, property management and building maintenance, construction management, energy efficiency and supply programs, and environmental assessments.[1]

The following sections describe the RESD organizational structure, new construction project type and volume, policies and programs related to commissioning, and DGS RESD commissioning experience.

[1] http://www.resd.dgs.ca.gov/default.htm

5.0 RESD Organizational Structure

The Real Estate Services Division (RESD), which is within the Department of General Services (DGS), provides real estate services to California state agencies.

RESD is full-service real estate organization. Its mission is to fulfill state agencies' facility and real property needs. This includes asset management and planning, property sales and acquisition, project management, architectural and engineering services, leasing and planning, property management and building maintenance, construction management, energy efficiency and supply programs, and environmental assessments. RESD provides opportunities for private sector companies to partner with the State on its many projects.

RESD manages over 24 million square feet of space in state owned or managed facilities. It's major capital outlay, special repair, and minor capital outlay projects encompass almost 1,200 projects valued in excess of $4.2 billion.

The following descriptions of branches within the DGS Real Estate Services Division (RESD) that are involved in delivering and operating buildings come from the following link within the DGS website: http://www.resd.dgs.ca.gov/Branches/default.htm. The organizational structure for the RESD is composed of the Deputy Director, Assistant Deputy Director, and five Branches.

5.1. Asset Management Branch (AMB)

The Asset Management Branch (AMB) provides service that meets the customer's needs regarding current ongoing services and when requesting new service. There are two sections within AMB. The *Asset Enhancement Section* identifies and implements value enhancement solutions for unused or underutilized State-owned properties. The *Regional Asset Management Section* has expert knowledge of local commercial real estate markets and provides inventory management of State-owned and leased real property assets. It performs initial screenings of proposed projects for consistency with regional facilities plans and develops rent structures for DGS-owned buildings. It also prepares long-term forecasts and develops regional plans and implementation strategies for future State office requirements. It also performs economic analysis for new projects. The section is divided into the following regions: Sacramento Region, Northern Region (North, Central, and Bay Area), and the Southern Region (Los Angeles, San Diego, and Inland Empire).

5.2. Project Management Branch (PMB)

The Project Management Branch (PMB) provides project management services for complex real estate projects. PMB manages the design and construction process on behalf of state agencies and departments [e.g., a PMB project director (PD) manages the current construction of the Caltrans building in Marysville]. PMB assists state agencies and departments in developing conceptual documents for cost and budget control, programming, site planning and master planning, and other documents for conceptualizing capital outlay projects that are necessary to obtain legislative authorization and funding projects.

5.3. Professional Services Branch (PSB)

The Professional Services Branch (PSB) includes all of the architectural and engineering services, space planning and interior design, leasing, sales, appraisals and acquisitions, construction services, cost engineering, environmental services, and other competencies such as seismic retrofits, asbestos abatement, and underground tank removal.

There are six sections within PSB. Two specific sections of immediate relevance with regard to the PIER DGS Commissioning Integration project are the *Design Services Section (DSS)* and the *Construction Services Section (CSS).* DSS and CSS would play significant roles in DGS in-house Commissioning activities for all scales of new buildings. These two sections, described subsequently, also should be trained more fully in use of the Commissioning Toolkit for Small Projects (see section 7.1 in this report). Sample duty statements for DSS and CSS are included in Appendix A.

5.3.1. Design Services Section (DSS)

The Design Services Section (DSS) provides the in-house planning architecture, engineering and interior design resources and services for the Department of General Services, state agencies and departments and other governmental clients. The Section is organized into nine design studios, each with specialized experience and capabilities in their respective fields, as follows:

- Space Planning - State-Owned Facilities -- Studio One
  Provides planning, interior design and architectural services for state agencies and tenants in state-owned buildings owned and managed by the Department of General Services.
- Space Planning Leased Facilities -- Studio Two
  Provides programming, space planning interior design and architectural services for state agencies and tenants in leased and agency owned buildings. Serves as lead in formulating and administering policy for facility health and safety issues such as asbestos, seismic safety, and ADA. Also responsible for research and development of policies on facility planning options such as hoteling, teleworking, and other alternative office design strategies.
- Architectural Design -- Studio Three
  Provides architectural design, planning and project management services for Capital Outlay (Major and Minor), Special Repair and Operations and Maintenance Projects for the Department of General Services and other state agencies and departments.
- Architectural Design -- Studio Four
  Provides architectural design, planning and project management services for Capital Outlay (Major and Minor), Special Repair and Operations and Maintenance Projects for the Department of General Services and other state agencies and departments. Provides ADA studies of compliance with ADA code. Provides landscape design and construction support.
- Architectural Design -- Studio Five
  Provides architectural design, 3D modeling, planning, construction administration and

project management services for Capital Outlay (Major and Minor), Special Repair and Operations and Maintenance Projects for the Department of General Services and other state agencies and departments.

Mechanical Engineering -- Studio Six

Provides complete mechanical consulting engineering services. Performs heating, ventilating and air conditioning (HVAC), plumbing, and central plant analysis, design and construction support. Other capabilities include HVAC and boiler controls, fire and life safety, backflow prevention, and elevator program management.

- Electrical Engineering -- Studio Seven
  Provides electrical design and construction support services. Conducts electrical power system studies and analyses, responsible for all phases of design of various projects consisting of lighting, power, signal, computer power systems, fire and life safety systems, security and surveillance systems, UPS, and emergency generator systems.
- Civil Engineering -- Studio Eight
  Provides civil engineering design services and construction support services. Conducts infrastructure studies, site investigations, property surveys, and topographical surveys. Provides surveys for grading, drainage, paving, ground improvements, athletic facilities, water supply treatment and distribution systems, sanitary sewer treatment and disposal systems, roads and trails, analyzes construction problems, environmental studies and remediation land fill closures.
- Structural Engineering -- Studio Nine
  Responsible for the structural adequacy of all buildings and appurtenant structures designed by Design Services. Prepares structural construction documents, structural calculations and analyses, conducts safety investigations of existing state buildings and writes reports thereon; checks shop drawings and material submissions for compliance.
- Quality Assurance - Studio 10
  Provide specifications for various projects, master specifications, boilerplate standards, professional standards for document production and efficiency, reference libraries, and product research. Provides quality reviews and constructability reviews and reviews Form 23s submitted by various agencies and the Roofing Analysis Program.

5.3.2. Construction Services Section (CSS)

The Construction Services Section provides nearly half of contract construction services and all direct construction services to customer agencies that have alternative sources of service. The CSS is comprised of two functional sections. They are:

- Construction Management/Inspection
- Direct Construction

CSS offers a full range of construction phase services for state public works projects. These services include:

- Construction Management
- Quality Assurance Inspection and Testing
- Code inspection to ensure compliance with applicable building codes and regulations
- After-Contract Guarantee enforcement and dispute resolution
- Direct Construction Services
- Rapid Design and Construction

Any combination of construction phase services is available to agencies that administer their own construction programs. Services are tailored to suit the strengths and weaknesses of the client agency's support staff, operational needs, scheduling requirements, budgetary constraints, and project sensitivity.

CSS offers Direct Construction Services for projects meeting the criteria specified in (Section 10122 of the Public Contract Code). Project criteria include cases of emergency involving damage to a state owned facility or instances in which the Director of General Services or his delegated representative has deemed contracting the work to be contrary to the best interests of the state. Work for which time is of the essence in order to maintain vital state operations, work around sensitive or secure facilities not suitable for contracting, and work with an undefined scope or unusual working conditions are normally considered to meet the criteria.

5.4. Building and Property Management Branch (BPM)

The Building and Property Management Branch (BPM) provides building management and administration, operations, maintenance, janitorial, groundskeeping, and repair services necessary to support the State´s Real Estate Assets. It includes an environmental health and safety unit which provides support services for meeting or exceeding regulatory compliance with asbestos, lead, chemical exposures, indoor air quality, hazardous waste, ergonomics, and other issues. It is responsible for managing state-owned buildings and properties in geographic locations where it is cost effective to do so.

It is important to note that BPM has a wealth of embodied knowledge of what works and what does not work in building systems and operation. This knowledge has value in the planning and design stages of new buildings. It is envisioned that BPM can play a significant role in in-house Commissioning activities at DGS. Also, with training, the Commissioning Toolkit for Small Projects (section 7.1 in this report) can assist BPM in its special repairs program and related efforts. Sample duty statements for positions within BPM relevant to building commissioning are included in Appendix A.

5.5. Business Operations, Policy and Planning Branch (BOPP)

The Business Operations Policy and Planning Branch (BOPP) provides common services to the Real Estate Services Division (RESD) that are unique to those provided at the Department level. These services support the programs and critical business processes of the Division's matrix-based operations and include, but are not limited to, contract management, human resources,

training, financial accounting and budget management, purchasing, customer billing, information systems, performance monitoring and reporting, and other operational support services.

6.0 DGS New Construction Projects

This section provides an overview of the size and types of buildings that the DGS delivers. This information provides a background for the later sections of this report that describe the commissioning activities appropriate to DGS projects, the type of KSAs required for these commissioning activities, the number of staff appropriate to handle the workload, and the recommended options for delivering commissioning on DGS projects.

The portfolio of DGS projects represented in Figure 1 changes over time, and this is a snapshot of projects in 2006. The set of projects listed includes only those that are new construction or major renovation and likely to require LEED certification. Some judgment was applied in reviewing the list, removing those that were nearing completion or those for which there was significant uncertainty whether commissioning was applicable. Most projects that appear to be smaller that 10,000 ft^2 are not included because they are not required to go through the LEED certification process.

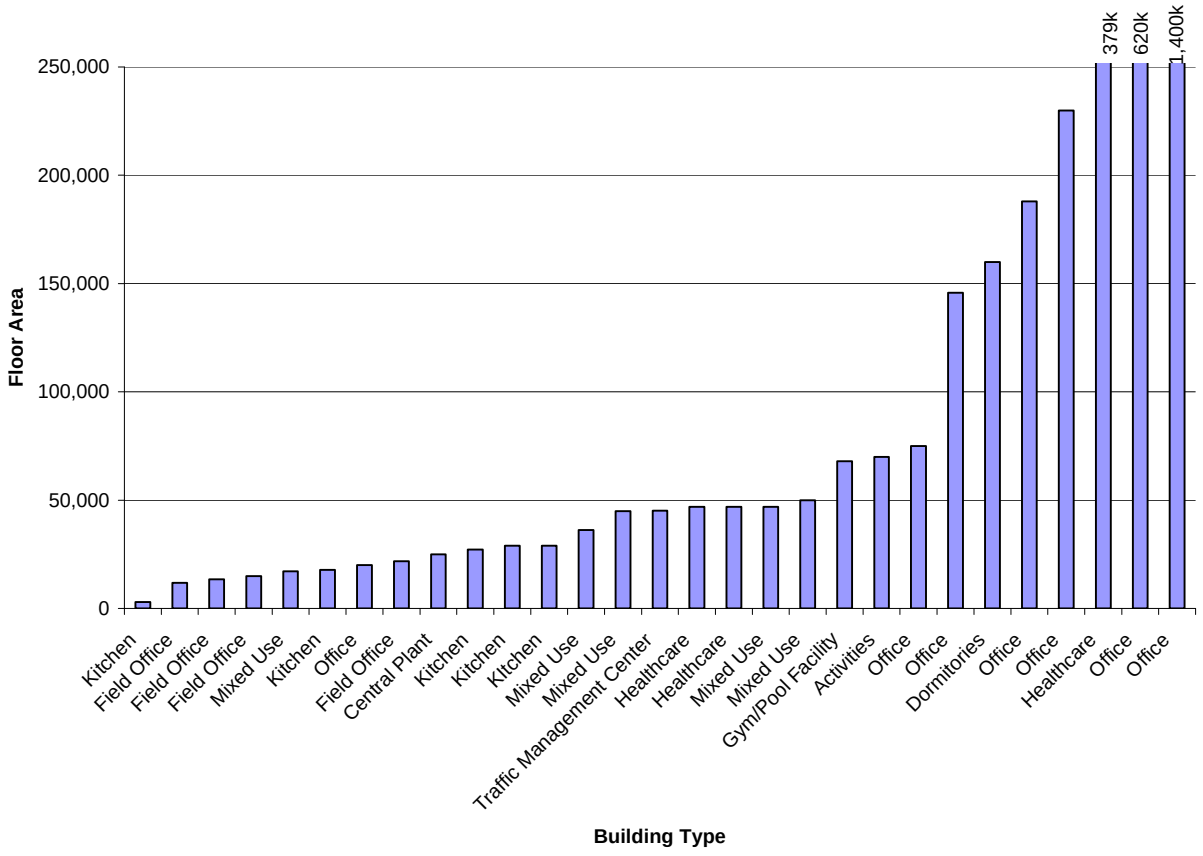

Figure 1. Floor Area Distribution and Project Type for DGS Projects[2]

2 Source: LEED Project Status Report 82306.xls, provided by Lewis Dean, DGS on June 18, 2007

The following are some relevant observations regarding this set of projects:

- This filtered list includes 29 DGS projects, totaling about 3.9 million square feet.
- 11 are offices (38%)
- 5 are mixed use (17%)
- 5 are kitchens (17%)
- 3 are healthcare (10%)
- Unique project types include central plant, traffic management center, gym/pool facility, and a dormitory.
- There are seven projects (24%) larger than 140,000 ft^2. Of these seven, five are offices, one is healthcare, and one is a dormitory.
- The remaining 22 projects (76%) are 75,000 ft^2 or smaller.

Some of the "clients" for these projects include the following agencies.

- Department of Motor Vehicles (DMV)
- California Highway Patrol (CHP)
- California Conservation Corp (CCC)
- Department of Veterans Affairs (DVA)
- Department of Mental Health (DMH)
- Department of Transportation (DOT)
- California Department of Forestry and Fire Protection (CAL FIRE)
- Department of Education (DOE)
- Department of Corrections and Rehabilitation (DCR)

7.0 State Programs

There are important state executive orders, legislation, and initiatives that are relevant to the realization of "green buildings" and their commissioning. Three significant ones are described below.

7.1. Executive Order S-20-04

Executive Order S-20-04 and its associated Green Building Action Plan include the requirement that all State buildings larger than 10,000 ft^2 achieve LEED certification at a level of Silver or better. LEED includes a prerequisite that requires commissioning. LEED also includes a "credit" for additional commissioning (See Section 11.0 for more information about LEED commissioning requirements). *Note: The effect of this policy is that a minimum level of commissioning is required for each of those projects.*

The executive order also addresses the State's existing buildings, and requires those 50,000 ft or larger to undergo a retrocommissioning process.

The Green Building Action Plan established the Green Action Team to oversee and direct progress toward the goals of the Governor's Green Building Executive Order S-20-04. Note: *The Green Building Action Plan describes the actions that support the Executive Order including recommendations for any additional actions, mandates or legislation that may be warranted to reduce grid-based energy purchases.*

7.2. Assembly Bill 32 (AB 32)

The *Global Warming Solutions Act of 2006* (AB 32, Nuñez/Pavley) was passed by the California Legislature on 31 August 2006 after the bill's authors, Assembly member Fran Pavley and Assembly member Speaker Fabian Nuñez, and Senate President Don Perata, announced they had reached an agreement with Governor Arnold Schwarzenegger on the landmark law. In June 2005, Gov. Schwarzenegger issued an executive order (S-3-05) that established a target for reducing global warming pollution to 1990 levels by 2020, and 80 percent below 1990 levels by 2050.

LEED, which is becoming the de facto standard for "green buildings," ensures that buildings have a lower carbon footprint. Thus, Executive Order S-20-04, which requires that new buildings be LEED certified at the silver level or higher, directly supports the mandated goals of AB 32.

Note: "The LEED rating system has become a de facto "green" label, but does not provide specific information on a building's energy or carbon performance.) Annual energy and carbon labels are needed for populated buildings on a whole-building basis to send signals to market players that actual (not just designed) building energy performance is of value in commercial building markets." (direct quote from CEESP[3]; see Section 6.3).

[3] http://www.californiaenergyefficiency.com

As law, AB 32 includes the following requirements:

Caps global warming emissions at 1990 levels by 2020 (a 25 percent reduction); establishes a mandatory reporting program to the Air Resources Board (ARB) for significant greenhouse gas emissions; requires ARB to adopt regulations for significant greenhouse gas emission sources (allowing ARB to design a cap and trade program) and gives ARB the authority to enforce the regulations beginning in 2012.

Initially, the Market Advisory Committee (MAC) has recommended that the California Air Resources Board choose from four programs for capping and thereby regulating sectors of California's economy. These four recommended programs are:

- Program 1 – Medium and Large Point Sources of Emissions
- Program 2 – Medium and Large Point Sources of Emissions and CO2 Emissions From Transportation
- Program 3 – Medium and Large Point Sources, CO2 Emissions from Transportation, and Upstream Coverage of Fossil Fuel Combustion by Other Sectors
- Program 4 – Upstream Coverage of CO2 from Fossil Fuel Combustion

The MAC has recommended linkages with the Regional Greenhouse Gas Initiative (RGGI) - a group of 10 northeastern US states, as well as the European Union Emissions Trading Scheme (EU ETS). Participants in both RGGI and the EU ETS have expressed interest in linking with the AB-32 program, but equivalently tight caps are necessary to assure environmental integrity in any linkage of programs.

In practice, a regulated entity under California's AB-32 would have four ways of complying with the program. These are:

1) Internal abatement - This means that the regulated entity would reduce actual direct emissions by switching to a less carbon intensive fuel or method of manufacturing.
2) Emissions trading - Trading allowances with other capped entities who may have excess permits because of a cleaner emissions profile
3) Investing in a carbon project - This option allows a regulated entity to invest in a project that reduces GHG emissions in an uncapped sector
4) Pay a carbon tax - This scenario is the do nothing scenario and is an unlikely choice. Basically, the capped entity would pollute beyond their cap and simply pay a compliance tax per ton at the end of the period. In the EU ETS this tax will be 100 Euro's per ton in 2008-2012.

7.3. California Energy Efficiency Strategic Plan (CEESP[4])

The California Energy Efficiency Strategic Plan (CEESP) is based on efforts by California's four investor-owned utilities (IOUs): Pacific Gas and Electric Company, San Diego Gas & Electric

[4] http://www.californiaenergyefficiency.com

Company, Southern California Edison, and Southern California Gas Company (the IOUs). CEESP was driven by California Public Utilities Commission (CPUC) Decision 07-10-032 (October 18, 2007). The CPUC order called for the IOUs to: "no later than February 1, 2008, jointly submit to the Administrative Law Judge assigned to this proceeding and the Energy Division a single statewide preliminary Strategic Plan as set forth in this Order" and to "file a final strategic plan as a joint application no later than May 15, 2008."

The fundamental vision is for California to have a long-term energy efficiency planning process that includes all principal stakeholders and defines strategies and goals supported by each stakeholder's short, medium and long-term plans and actions. There are three pillars for the plan:

1) Energy is used extremely efficiently by energy consumers (note: this pillar is consistent with the notion of radical efficiency as laid out in the book *Natural Capitalism*[5]).
2) All cost-effective, reliable, and feasible energy efficiency measures and actions are implemented in an integrated manner.
3) Energy efficiency generates significant reductions in greenhouse gas emissions (note: in support of AB 32).

The CEESP vision "pushes the envelop" and embraces CPUC's three "*Big Bold Energy Efficiency Strategies*:"

1) All new residential construction in California will be zero net energy by 2020.
2) All new commercial construction in California will be zero net energy by 2030.
3) Heating, Ventilation and Air Conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California's climate (note: this will entail design and market transformation to achieve radical improvement over incremental advances).

The CEESP covers 12 basic categories of strategies:

1) Residential Sector Strategies
2) Commercial Sector Strategies
3) Industrial Sector Strategies
4) Agricultural Sector Strategies
5) Heating, Ventilation and Air Conditioning Strategies (HVAC)
6) Codes and Standards Strategies (C&S)
7) DSM Coordination and Integration Strategies
8) Workforce Education and Training Strategies (WE&T)
9) Marketing, Education and Outreach Strategies (ME&O)
10) Emerging Technologies Strategies (ET)

[5] *Natural Capitalism* (1999), Hawken, P., A. Lovins, and L.H. Lovins (Little, Brown and Company)

11) Roles of Local Government
12) Low Income Energy Efficiency Strategies (LIEE)

Of these categories of strategies, the PIER DGS Commissioning Integration project is most impacted by the commercial sector strategies, HVAC strategies, codes and standards strategies, workforce education and training strategies, and emerging technologies strategies.

The CEESP vision and goals for commercial buildings embodies the important aspects of the strategies relevant to the PIER DGS Commissioning Integration project:

7.3.1. Vision

Commercial buildings will be put on a path to zero net energy by 2030 for all new buildings and for many existing ones. Innovative technologies and practices will dramatically grow in use in the coming years through a combination of technology development, financing and incentives, Codes & Standards and market pull.

7.3.2. Goals

- All new construction building starts and a significant number of existing buildings will be zero net energy by 2030.
- The HVAC industry is transformed to yield optimal performance for systems used by commercial consumers.
- Markets provide both demand "pull" and supply "push" for zero net, and ultra low, energy buildings.
- Utility programs are integrated and provide price signals, financing mechanisms & other incentives for owners/managers & builders/producers of zero-energy buildings
- CPUC, IOUs, CEC, et al use the vision statement as basis for long-term strategic planning & actions, assuring other market participants of their goals and intents thru 2030.

The CEESP is a "living" document that will change based on market, policy, and technological conditions.

"The goals and vision of the Plan can only be achieved through continual incorporation of efficiency gains into Codes & Standards and increasing commercialization of cost-effective energy efficiency services and collaboration/support from all stakeholders." (direct quote from CEESP)

8.0 DGS Policies and Programs

The following policies and programs support commissioning and the development of in-house Commissioning capabilities at DGS.

8.1. Small Building Commissioning Toolkit

DGS has developed a process for commissioning of buildings smaller than 10,000 ft^2, which are not required to be LEED certified but are still expected to meet LEED criteria. That process relies on DGS staff to perform the tasks required to meet the LEED commissioning prerequisite requirements. In a typical project, an engineer from the Design Services Section (DSS) of the Professional Services Branch (PSB) would perform design-phase tasks, and an inspector from the Construction Services Section (CSS) of PSB would take over for construction phase work, including overseeing of the contractor's functional testing. Details of this process may be found at http://www.green.ca.gov/CommissioningToolKit.

8.2. Facility Performance Evaluation (Post Occupancy Evaluation)

DGS has an Excellence in Public Buildings program (http://www.dsa.dgs.ca.gov/OtherProg/eipb.htm) that includes Facility Performance Evaluation (FPE) as one element[6]. Facility Performance Evaluation assesses the experience of the occupants and building operators, with the goal of making improvements to that building as well as recording lessons learned for future projects.

A commissioning process typically includes a review of system operation during the warranty period, which can be an excellent complement to the FPE process.

8.3. Evaluation and Implementation of In-House Building Commissioning at DGS

In compliance with Executive Order S-20-04, the California Energy Commission (CEC) has funded the PIER DGS Commissioning Integration program to evaluate and implement the development of in-house commissioning at DGS. This report represents Task 2 of seven tasks to explore this goal.

[6] http://www.documents.dgs.ca.gov/dsa/pubs/eipb.pdf

9.0 DGS Commissioning Experience

This section describes how commissioning is being performed on current DGS projects and describes the costs for that process to the extent available. A brief summary of the process and experience for some completed projects is also included. A consistent theme stated by DGS personnel in virtually all branches and sections interviewed is that the success of building commissioning suffers from budgetary constraints and lack of cooperation from construction contractors.

9.1. Current Commissioning Approach

Since 2004 and the signing of Executive Order S-20-04, third-party commissioning authorities have been used for most projects larger than 10,000 ft^2.The scope of commissioning on these projects is intended to comply with the LEED commissioning prerequisite and in some cases also the LEED enhanced commissioning credit.

9.2. DGS Commissioning Costs

Note: Data for this section of the report will be provided by Lewis Dean of PMB and Dan Burgoyne of the DGS Green Team.

9.3. Specific Commissioning Past Project Experience

9.3.1. Capital East End Project, Sacramento

Commissioning authority worked for the contractor.

The inspectors from the Construction Services Branch spent significant time alongside the commissioning authority. Was to be completed based on DGS provided information.

9.3.2. Caltrans District 7 Project, Los Angeles

Was to be completed based on DGS provided information.

9.3.3. California EPA Project, Sacramento

Was to be completed based on DGS provided information.

9.3.4. Franchise Tax Board, Sacramento (Butterfield Commissioning Project)

This project was done about four years ago. The Commissioning project lost its funding, so the intent to provide DGS staff training and maximizing return on investment was not achieved. Also, the experience showed that contractors give "lip service" to Commissioning but don't really take it seriously. Contractor resistance or lack of response is a consistent theme, and is abundantly apparent with the Caltrans construction process at Marysville. There seems to be a continuous disconnect between DGS's vision on the role and importance of Commissioning and contractor behavior.

9.3.5. Department of Motor Vehicles, San Ysidro

Was to be completed based on DGS provided information.

10.0 Commissioning at Other Institutions

During development of this report, information about commissioning approaches at other institutions was collected using interviews and Internet-based literature review. This section provides a brief summary of those findings.

10.1. University of California Davis

All new construction projects on campus are commissioned by University staff. The exception is specific types of projects (e.g. boiler plants) that the university staff does not have expertise to perform. These specific projects are sub-contracted.

Medical school projects are also typically commissioned in-house. However, they are commissioned to the standards of a new construction project, not of a working medical facility. Depending on the situation, further commissioning is conducted by a third party. In addition to the medical school facilities in Davis, UC Davis owns a teaching hospital that is remotely located (Sacramento). The interviewee could speak about medical school facilities on campus in Davis, but not for the hospital in Sacramento.

UC Davis has a staff classification of Commissioning Analyst under the Quality Assurance group which is a part of the Commissioning and Engineering classification. Other than this classification, there are not specific civil service levels or job duty statements that come into play for UC Davis' commissioning activities.

Descriptions of the UC Davis Commissioning Analyst position and Senior Engineer position are included in Appendix B.

Contacts: Peter Shahrokh, (530) 297-4483, commissioning analyst. John Coon, (530) 754-4815, primarily responsible for training of craftspeople, etc. for proper O&M of new systems and facilities.

10.2. University of Minnesota

About 60-70 percent of the commissioning services at the University of Minnesota are performed in-house. The remaining projects (30-40%) are sub-contracted. To make this possible, much of the document review and reporting involved in the commissioning process has been eliminated to reduce costs. Energy management staff already reviews documents of this nature. Therefore, with a small addition to their workload, redundancy is prevented. Not much more additional effort is required to review documents for commissioning purposes. They have focused their energy on construction review and startup. A downside is that more time is focused on the back side of projects. The university has available dedicated technical, maintenance, and construction management staff that makes this overall process much easier.

A PowerPoint presentation describing lessons learned is available on the Internet: http://www.commissioning.org/downloads/UnivofMinnCommissioning-LessonsLearned.ppt. This presentation summarizes lessons learned from commissioning projects at the Univ. of

Minnesota. Among the issues include the experience that with third-party commissioning, many problems were documented but not fixed. They also note that with an in-house commissioning authority, it is easier to keep them involved through the warranty period

Contact: Jay Denny, Univ. of Minnesota, denn0013@umn.edu, 612-624-3554.

10.3. The University of Iowa

The University of Iowa started phasing in-house commissioning into the scope of their activities as of July 1, 2007. Therefore, they do not yet have very extensive information on how it will work.

A major thrust of the new strategy for the University of Iowa is combining commissioning activities with controls checks. A major problem that developed is that the controls engineers would not do a thorough job knowing that University staff would be coming through to check their work (as a part of the commissioning process). By combining the controls work with the commissioning tasks, a redundant step is taken out.

The major obstacle to implementation is lack of staff. Only time will tell whether existing staff and resources can get up to speed with the necessary commissioning activities and tasks that will need to be completed.

The University of Iowa may conduct commissioning a little differently than a lot of organizations in that they focus on results versus deliverables. They typically do not produce large reports and documents thinking they are unnecessary.

In the University's energy plan, commissioning is identified as strategy number 10. http://www.facilities.uiowa.edu/Energy/EnergyPlanFeb2007.pdf

Contact: Daniel Oppelt, (319) 335-5809, daniel-oppelt@uiowa.edu. Mr. Oppelt is the manager of building commissioning and controls within the department of utilities and energy management.

10.4. Sandia National Labs

A paper by Ralph Wrons, Sandia National Laboratory, "Developing and Keeping In-house Commissioning Expertise", is a case study involving commissioning a wide range of buildings (offices buildings to clean rooms) at Sandia National Laboratories, New Mexico. (Ralph Wrons, National Conference on Building Commissioning: May 4-6, 2005)

The paper describes a four-tier approach to assigning a commissioning authority based on the type of project:

- Contract commissioning service provider for large projects
- A/E firm for mid-range projects
- In-house team for small D/B and design-bid-build
- Inspectors for small replacement projects

10.5. Emory University

Within the facilities management hierarchy there is a manager of building commissioning position. However, this position is vacant at the time of this report.

There are two documents on the Emory University website with information related to commissioning approach.

- Facilities Management Guide to Services: http://www.fm.emory.edu/guidetoservices.pdf, Standards and Commissioning- Page 25
- Design and Construction Standards: http://www.fm.emory.edu/emory-std/2006%20Emory%20Design%20&%20Construction%20Standards.pdf, Section 01810- Commissioning- Page 23 of PDF

Contacts: Jody DiCarlo, Utilities manager- jody.dicarlo@emory.edu. Bob McMains, VP of Facilities Management- bob.mcmains@emory.edu.

11.0 Overview of Commissioning Activities

This section describes the commissioning activities that are generally appropriate for DGS projects. Also listed are the building systems that might be included in the commissioning process. The intent is that the activities comprise a "total building commissioning process" and that these activities are also consistent with the LEED commissioning prerequisite and additional credit. In addition, this list of activities is organized to correlate with the DGS building delivery process and incorporate DGS terminology to describe project phases.

The listed activities are intended to represent commissioning best practices. However, commissioning is an evolving discipline, and there will always be some differences in approach among commissioning professionals. To help ensure consistency with industry standards, the authors of this report have consulted the following sources when compiling the information in this section.

- ASHRAE Guideline 0-2005, The Commissioning Process
- LEED-NC Green Building Rating System for New Construction & Major Renovations, Version 2.2
- LEED-NC For New Construction Reference Guide, Version 2.2
- California Commissioning Guide: New Buildings. California Commissioning Collaborative.

11.1. Building Systems Included in Commissioning

The following systems are the minimum required to meet LEED criteria:

- HVAC. Includes overhead and under floor air distribution systems, boilers, chillers, pumps, VAV boxes, economizers and controls.
- Building Automation Systems. Includes Energy Management System (EMS) and energy monitoring equipment.
- Lighting and lighting control. Includes motion sensors, photocell control, programmable time controls.
- Water heating. Includes water heaters, boilers, pumping systems, and controls.
- Renewable energy. Such as photovoltaic systems, solar thermal systems, and wind turbines.

Additional systems to be included in a total building commissioning process include the following:

- Accessibility. Includes path of travel (including site) incorporation of Title 24 and ADA requirements for handicapped, ambulatory and semi-ambulatory individuals. Systems include ramps, lifts, elevators, stairways, restrooms, kitchens, offices, seating, etc.

- Fire / Life Safety. Includes fire suppression systems, fire alarm and monitoring systems, including controls, and exiting.
- Indoor Air Quality. Includes the establishment of requirements for low emissions of materials and products utilized inside facility. Also includes monitoring of indoor air emissions, carbon dioxide, and outside air intake.
- Electrical. Includes lighting and power distribution systems, as well as transformers and sensors. Also includes emergency generator systems.
- Plumbing. Includes roof, site and storm drainage, water supply and waste systems. Also finish plumbing fixtures and hardware.
- Telecom & Data. Includes telephone, data network, LAN, servers, etc.
- Structure. Includes foundation, seismic, and structural framework.
- Envelope. Includes roofing, glazing, exterior finish (cladding), waterproofing, and exterior door systems.
- Landscaping & Irrigation. Coordination of planting, irrigation, controls and landscape drainage. May include landscape lighting.
- Acoustics. Includes the coordination of various wall assemblies and finishes to achieve desired acoustic levels within spaces. Also may include coordination of glazing acoustical characteristics in areas with high noise. May include placement of public address speakers.

11.2. LEED-NC 2.2 Commissioning Scope

The following are the minimum commissioning activities required for a project pursuing LEED certification.

- Designate a Commissioning Authority
- Develop Owner's Project Requirements and Basis of Design documentation
- Include commissioning requirements in the construction documents
- Develop and utilize a Commissioning Plan
- Verify installation, functional performance, training and documentation
- Complete a Commissioning Report

To earn the LEED credit for Enhanced Commissioning, the following additional requirements apply:

- Designate an independent Commissioning Authority
- Conduct a focused review of the design prior to the mid-Construction Documents Phase
- Conduct a focused review of the construction documents when close to completion
- Conduct a selective review of contractor submittals of commissioned equipment
- Develop a system and energy management manual
- Have a contract in place for a near-warranty end or post occupancy review

11.3. Commissioning Activities

Commissioning activities occur throughout the project timeline. The following table lists typical activities and identifies the project phase where they should take place. The party responsible for leading or participating in the task is also identified.

The commissioning activities listed in Table 1 correspond to a design-bid-build project delivery process, in which working drawings are completed by a design team prior to contractors bidding on the job. However, some State projects use different delivery processes such as design-build. The commissioning activities in those cases will be essentially the same, but the design review and submittal review process will be slightly different. *In Tasks 4 & 6, a more detailed look will be given to design-build and design-bid-build projects.* Additionally, it would be important to explore as-built and build-to-suit scenarios within DGS in Tasks 4 & 6, as well.

Table 1. Typical Commissioning Activities

Commissioning Activity	Timing (Project Phase)	Responsibility	Notes
Designate Commissioning Authority (CommissioningA)	C/B or PP	Project Director	The CommissioningA role is to lead, review, and oversee commissioning activities, and this individual does not necessarily have to perform all activities directly. Should be involved from beginning of design (or even budget package development) through warranty period. If LEED enhanced commissioning credit to be pursued, then design team is not an option and the CommissioningA must personally perform design reviews, submittal reviews, and warranty period review. See the LEED 2.2 Reference Guide for more details.

Commissioning Activity	Timing (Project Phase)	Responsibility	Notes
Owner's Project Requirements (OPR)	C/B	Project team, lead by Project Director, with CommissioningA review	Develop OPR as part of the budget package, expanding on typical building program information. Includes information such as sustainability goals, energy efficiency goals, indoor environmental quality requirements, equipment and system expectations, desired level of training, and operating staff capabilities.
Commissioning Plan	C/B or PP	CommissioningA	The commissioning plan describes the approach to commissioning for the project, including roles, responsibilities, systems to be commissioned, tasks, and schedule. Include as attachment to the Project Management Plan. The plan should be developed early in the project, then updated throughout the process as appropriate
Basis of Design (BOD)	PP or WD	Design Team, with CommissioningA review	Describe systems and design assumptions and describe how they meet the OPR.
Commissioning Specifications	WD	Design Team, with CommissioningA review	Include the contractor's participation requirements in the specifications.
Design Review	WD	CommissioningA	Not required for LEED prerequisite.

Commissioning Activity	Timing (Project Phase)	Responsibility	Notes
Commissioning Kick-off Meeting	Const.	Lead by CommissioningA, attended by Contractor	Review the commissioning requirements and the schedule with Contractor. Can be combined with other early construction phase meetings.
Commissioning submittals review	Const.	CommissioningA	Not required for LEED prerequisite. Selective review of submittals related to systems being commissioned.
Develop pre-functional checklists	WD or Const.	CommissioningA	The CommissioningA develops checklists (start-up sheets, TAB, controls checkout) and provides to the Contractor.
Develop functional test procedures	WD or Const.	CommissioningA	The CommissioningA develops test procedures and forms for recording test results. Forms are provided to Contractor for review.
Complete prefunctional checklists	Const.	Contractor, with CommissioningA (or Inspector) review	Completed and signed by Contractor indicating that installation is complete for each system being commissioned and that the system is ready for testing.
Perform functional performance testing	Const.	Contractor, with CommissioningA (or Inspector) guidance, witness and approval	Contractor executes tests under guidance of CommissioningA. Deficiencies are noted by CommissioningA. Retesting performed after Contractor corrects any deficiencies.
Verify training	Const.	CommissioningA, Inspector, or Project Director	Verify that Contractor has provided training as required in the construction documents.

Commissioning Activity	Timing (Project Phase)	Responsibility	Notes
Verify O&M Documents	Const.	CommissioningA, Inspector, or Project Director	Verify that O&M documentation provided by Contractor meets requirements in construction documents.
Commissioning acceptance	Const.	CommissioningA	CommissioningA provides certification that commissioning tasks have been completed successfully.
Final Commissioning Report	Const.	CommissioningA	Report includes executed prefunctional checklists, completed functional test forms, and a record of deficiencies and resolutions. Also includes CommissioningA certification of acceptance. Attach OPR and BOD. Include recommendations for End-of-Warranty Review activities.
End-of-warranty review	Warranty	CommissioningA or Inspector	Perform selected inspections and functional tests as part of typical pre-expiration review or warranties.

Table Notes:

CommissioningA = Commissioning Authority

Project Phases: C/B = Concept/Budget, PP = Preliminary Plans, WD = Working Drawings.

12.0 Commissioning Authority Qualifications

This section describes desired qualifications for a commissioning authority and presents the information in the format similar to a DGS staff duty statement. A typical salary range for commissioning authorities is also presented. The intent of this information is to help the DGS identify existing staff classifications and/or define new staff positions that can provide commissioning services.

Successful commissioning authorities come to the role from a number of different backgrounds. Regardless of their background, there are several characteristics that are especially valuable.

- Fundamental knowledge of how building systems and their controls function
- Understanding of both design and construction processes
- Ability to manage complex long-term projects
- Sufficient experience to earn respect from both the design and the construction teams
- Personal qualities that enable one to be a problem solver in a "politically" charged environment

12.1. Commissioning Authority Duty Statement

The information in this section is arranged in a similar format to a typical DGS staff duty statement.

12.1.1. Essential Functions

Serves as commissioning authority for State commercial and institutional construction projects. Performs commissioning authority role for four to eight projects at any one time, depending on project size, with projects typically at different phases in the planning, design, and construction process. As commissioning authority, provides the following essential functions:

- Assists project director in documenting Owner's Project Requirements, especially with regards to sustainability, energy efficiency, and indoor environmental quality goals.
- Prepares commissioning plans.
- Performs design review to ensure that owner's project requirements are satisfied and to identify potential improvements in system performance.
- Reviews basis of design documentation produced by the design team to ensure that owner's project requirements are satisfied.
- Develops or reviews commissioning specifications that describe contractor's commissioning requirements and are to be included in the contract documents.
- Develops inspection checklists and testing plans for systems to be commissioned.
- Reviews contractor submittals for systems to be commissioned.
- Leads commissioning coordination meetings.
- Ensures that commissioning activities are included in the project schedule.

- Schedules, observes and approves system testing performed by contractor.
- Maintains issues log throughout the project recording issues and resolutions.
- Coordinates warranty period inspections and testing
- Verifies that training is provided to building operators as required by contract documents.
- Verifies that operations and maintenance manuals meet requirements in contract documents.
- Creates a commissioning report recording testing results and summarizing commissioning process.

12.1.2. Marginal Functions

- Submits documentation to the US Green Building Council related to commissioning prerequisites and credits required for LEED certification.
- Obtains training necessary to maintain commissioning skills and keep them up to date.
- Contributes to development of DGS commissioning policies and procedures.
- Provides budgetary information related to commissioning for use in project planning

12.1.3. Knowledge and Abilities

Knowledge of: Building commissioning industry standards and guidelines; design process for commercial, institutional, and industrial construction; energy-efficient building design strategies for mechanical, lighting, water heating, and building envelope systems; methods and procedures for testing performance of mechanical and electrical systems in buildings; Leadership in Energy and Environmental Design (LEED) green building rating system; project constructability; and building control system design and operation.

Ability to: Read and write English at a level required for successful job performance; develop commissioning specifications; develop commissioning plans; review building plans, drawings, and specifications; develop and implement testing plans for building system performance; recognize proper construction techniques and evaluate quality or workmanship; recommend alternative approaches to improve efficiency or constructability; lead meetings to coordinate commissioning activities; compile clear and accurate commissioning process results; and manage multiple projects at the same time.

12.1.4. Desirable Qualifications

- Possession of a valid certificate of registration as an mechanical or electrical engineer issued by the California Board of Registration for Professional Engineers and Land Surveyors
- Possession of a valid California Drivers License, Class C
- Knowledge of Title 24, the California Building Standards Code, NFPA
- Proficiency with MS Office (Word and Excel)

12.1.5. Interpersonal Skills

- Display efficiency, effectiveness, conscientiousness and professionalism.
- Ability to gain the confidence, trust and support of a diverse group of people in order to reach established goals.
- Excellent oral and interpersonal communication skills to work as a team member to communicate in a pleasant, professional and effective manner; and to handle difficult, sensitive, and/or confidential issues.
- Strong skill to organize work effectively to achieve a timely progress on multiple simultaneous projects. Ability to work independently and follow through on assignments with minimal direction.

12.1.6. Additional Desirable Qualifications

- Valid certification as a Certified Commissioning Professional from the Building Commissioning Certification Board
- Experience with commissioning building and central plant systems.
- Experience designing, installing and operating building control systems.
- Experience designing building mechanical systems.
- Ability to apply energy analysis to new construction, alterations and modifications.
- Working knowledge of energy models and related computer software.
- Experience with measuring and monitoring voltage, electric current, electric power, temperatures, flows, and illumination for the purpose of evaluating building system performance
- Experience processing and analyzing large qualities of data to evaluate building system performance

12.1.7. Work Environment, Physical or Mental Abilities

- Professional office environment
- Walk on uneven ground and around objects/materials scattered on the ground.
- Climb ladders or ships ladders.
- Ability to move the neck in an unrestricted manner from the front to back and from side to side in order to perform duties.
- Reaching by extending hand(s), arms(s) and foot/feet in any direction.
- Manipulate small components and controls using fine motor skills/manual dexterity.
- Visually inspect construction sites and workmanship.
- Hear within normal range for safety purposes in a construction area.
- Work in a noisy, vibration, dusty, machinery filled environment typical of a construction site.
- Walk or stand for extended periods of time.
- Work in inclement weather conditions.

- Travel and work overtime as needed.
- Daily use of a personal computer and/or laptop and related software applications.
- Bend, stoop, kneel and lift 50 lbs.
- Use a digital camera.
- Sit for extended periods of time driving from project site to project site.
- Carry a cell phone.

12.2. Commissioning Authority Salaries

Commissioning industry salary surveys could not be identified during this study. Commissioning is a relatively young practice compared to related fields of design engineering and construction, making publicly available information more difficult to find. Therefore, the salary estimates here are based on anecdotal information and an informal review of Internet job postings.

For a senior commissioning engineer, with roughly 10 years of general industry experience and several years of commissioning experience, annual salaries fall in a range of $85,000 to $120,000. Bonuses or profit sharing are often provided and are in addition to these amounts. These jobs typically include standard benefits. One Internet job listing that included significant management responsibilities included a range up to $150,000.

For comparison, Table 2 lists salary ranges for selected DGS staff classifications, as of October 2007. Classifications that appear to match up well with industry commissioning authorities salaries include Construction Supervisor II and III, Supervising Mechanical Engineer and Senior Mechanical Engineer.

Table 2. DGS Salary Ranges for Selected Classifications (October 2007)

Classifi-cation ID#	Description	Annual Salary Low	Annual Salary High
4029	Construction Supervisor III	$97,164	$118,104
4023	Project Director III	$97,164	$118,104
3578	Supervising Mechanical Engineer	$97,164	$118,104
4020	Project Director II	$88,452	$107,460
3579	Senior Mechanical Engineer	$88,452	$107,460
4770	Assistant Chief, Office of Real Estate and Design Services	$89,436	$100,920
4030	Construction Supervisor II	$81,444	$99,000
3583	Mechanical Engineer D	$75,240	$91,404
4019	Project Director I	$75,252	$91,392
4031	Construction Supervisor I	$71,280	$86,568
6671	Office Building Manager IIII	$75,300	$83,016
3583	Mechanical Engineer C	$67,248	$81,684
6672	Office Building Manager III	$63,744	$76,908
6749	Chief of Plant Operation III	$63,432	$76,572
6750	Chief of Plant Operation II	$60,588	$73,032
6698	Chief Engineer I B	$71,640	$71,640
6695	Chief Engineer II	$56,724	$68,472
4032	Construction Inspector II	$56,088	$68,160
4037	Mechanical Inspector II	$54,036	$65,676
6698	Chief Engineer I A	$65,160	$65,160

Source: http://www.spb.ca.gov/employment/spbpayrd.htm

13.0 Projected DGS Commissioning Staff Requirement

This section presents an estimate of the number of commissioning authorities who would be needed to serve the current DGS workload. The number and type of relevant DGS projects was presented earlier in Section 5.0.

First, the commissioning authority staff hours are estimated for several typical projects. Next, based on those estimates a simple relationship is presented for estimating hours required for commissioning as a function of project size. Finally, that simple function is applied to each DGS project identified in Section 5.0 to provide an estimate of the total number of commissioning authorities required.

13.1. Commissioning Authority Time Estimate for Typical Projects

The following generic building types were defined for this analysis, with the intent that they cover the range of typical DGS projects.

- Large office. 200,000 ft^2; HVAC: built-up VAV system
- Medium office. 50,000 ft^2; HVAC: packaged VAV system
- Small office. 20,000 ft^2; packaged single-zone HVAC units
- Healthcare/Laboratories. 200,000 ft^2; multiple complex systems
- Campus facility. 200,000 ft^2; 10 buildings; administration, dormitory, kitchen; packaged single-zone HVAC units

Table 3 shows an estimate of the hours of commissioning authority time required for these five typical projects. The activities listed in the table are essentially the same as those described earlier in Section 11.3. These estimates are based on consultant experience and assume a level of effort that meets the requirements of LEED-NC v2.2 fundamental commissioning prerequisite and enhanced commissioning credit.

The systems covered by this time estimate are those required by LEED: HVAC, lighting, water heating and renewable energy. The time would need to be increased to cover a total building commissioning process that includes additional building systems as described in Section 11.1. As a rough estimate, the additional design review, submittal review, testing, and documentation would add about 50 percent to the estimated hours in Table 3.

Another factor affecting the time estimate is travel. The estimate in Table 3 assumes that the commissioning authority can reach the site within about one hour from his or her office. For remote sites, the extra travel time for site visits would add between 3 percent and 10 percent to the time estimate.

Table 3. Commissioning Authority Time Estimates for Typical Projects (hours)

	Large Office (200,000 ft²)	Medium Office (20,000 ft²)	Small Office (20,000 ft²)	Hospital (200,000 ft²)	Campus (200,000 ft²)
Design Phase					
Commissioning plan	20	12	8	30	20
Owner's project req. review	12	8	6	16	12
Basis of design review	12	8	6	12	16
Commissioning specifications	8	8	6	16	12
Design review	60	40	24	100	80
Subtotal	112	76	50	174	140
Construction Phase					
Meetings/coordination	140	80	40	180	160
Submittal review	32	24	8	40	32
Construction observation	100	60	16	160	120
Prefunctional checklists	60	40	24	120	80
Functional performance tests	220	160	60	320	200
Systems manual	36	24	12	80	40
Commissioning report	28	20	12	40	32
Training verification	12	12	8	16	12
LEED documentation submittal	6	6	6	6	6
Subtotal	634	426	186	962	682
Warranty Period					
Deferred seasonal testing	40	16	16	80	80
End-of-warranty review	80	32	32	120	120
Subtotal	120	48	48	200	200
Total Hours	**866**	**550**	**284**	**1336**	**1022**
Typical Project Duration (years)	**3**	**2.5**	**2**	**4**	**3**
Average hours per year	**289**	**220**	**142**	**334**	**341**

Source: Architectural Energy Corporation estimate. Corresponds to effort required for LEED-NC v2.2 Fundamental and Enhanced commissioning.

Figure 2 presents another view of the information in Table 3. The figure plots the commissioning authority time estimates for each project versus the size of the project. The upper series in the plot is the total hours per project, and it can be seen that there is a bit of variation due to the varying complexity of projects of the same size. The lower series in Figure 2 shows the commissioning authority hours per year for each project. In this case there is less variation because the complex projects tend to last longer. (See Table 3 for the estimated typical project duration for each of these projects).

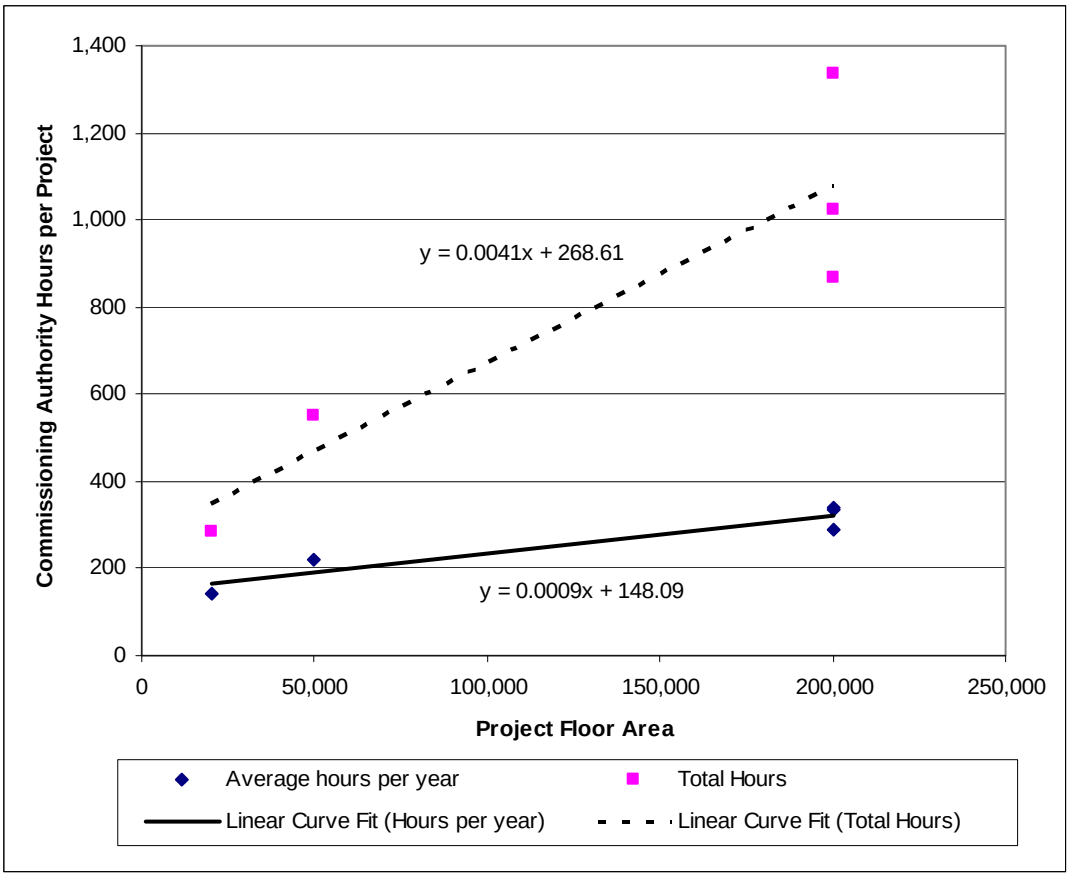

Figure 2. Plot of Commissioning Authority Hours versus Project Size

13.2. Number of Commissioning Authorities Needed for DGS Projects

The relationship illustrated in Figure 2 between project size and hours of staff time can be used to develop a rough estimate of the number of commissioning authorities who would be needed to serve the DGS project workload. The equation shown in Figure 2, y = 0.0009x + 148.09, can be used to estimate the hours required for each project as follows:

Commissioning Authority Hours per Year = (0.0009 x Project Floor Area) + 148

Table 4 applies this equation to the list of DGS projects presented earlier in Section 5.0 of this report. The estimate of time required for each project ranges from 151 to 1408 hours per year, and the total time for all projects is 7,787 hours per year.

Assuming that a commissioning authority will have about 1,600 hours per year available for project work, this workload of 7,787 hours per year would require five people.

This analysis does not directly address the fact that some commissioning tasks can be performed by a junior engineer under the direction of a commissioning authority. As a rough estimate, about 20 percent of the work on a typical project could be performed by an entry-level engineer. Therefore, one of the five staff required to meet the DGS workload could be a junior

engineer supporting four commissioning authorities. Or from another perspective, four commissioning authorities could handle the workload if supported by other technical staff.

Table 4. Commissioning Authority Time Estimates for DGS Projects

Project Type	Floor Area (square feet)	Commissioning Authority Time (hours per year)
Kitchen	3,000	151
Field Office	11,800	159
Field Office	13,541	160
Field Office	15,000	162
Mixed Use	17,200	163
Kitchen	17,800	164
Office	20,000	166
Field Office	21,827	168
Central Plant	25,000	171
Kitchen	27,232	173
Kitchen	29,000	174
Kitchen	29,000	174
Mixed Use	36,231	181
Mixed Use	45,000	189
Traffic Management Center	45,144	189
Healthcare	47,000	190
Healthcare	47,000	190
Mixed Use	47,000	190
Mixed Use	50,000	193
Gym/Pool Facility	68,000	209
Activities	70,000	211
Office	75,000	216
Office	145,800	279
Dormitories	160,000	292
Office	188,000	317
Office	230,000	355
Healthcare	379,000	489
Office	620,287	706
Office	1,400,000	1,408
Total	**3,883,862**	**7,787**

14.0 DGS Commissioning Staffing Alternatives

There are many alternative paths for providing commissioning services on DGS projects. The following three general approaches are discussed in this section.

- In-house commissioning authorities
- In-house commissioning project managers
- Third-party contractor commissioning authorities

Some of the advantages and disadvantages to each approach are also discussed below.

14.1. In-house Commissioning Authorities

Under this approach, DGS staff would serve as commissioning authority for the majority of projects. As described in Section 13.0, it is likely that about five in-house commissioning authorities would be required to handle the DGS project workload.

Due to the wide variety of project types, such as hospitals, offices, and laboratories, there may be specific projects where outside expertise would still be appropriate. Therefore, third-party contractors would likely provide supplementary assistance in some cases.

During a transition period, it is also likely that third-party contractors would provide commissioning for some projects while DGS staff capabilities are developed.

The appropriate DGS branch where the commissioning authorities would reside will need to be determined.

14.1.1. Cost Issues

There are several elements to the cost of in-house commissioning, however the primary cost is the salaries of the commissioning authority. This cost can be viewed from two different perspectives. One perspective is the cost to individual projects, to which commissioning services are provided at an internal billing rate (reported to be $163 per hour). A second perspective is the direct salary and overhead cost to DGS for the in-house commissioning authorities.

Other costs associated with in-house commissioning are the following

- Administrative time required for recruiting and hiring commissioning staff
- Training expenses
- Equipment expenses, such as measurement and monitoring devices

14.1.2. Advantages

- Retained knowledge to inform future projects
- Reduced contracting cost
- Consistency in approach
- Greater access to expertise throughout life of building

- Potential to regionalize knowledge base
- Synergy with the State's retro-commissioning efforts
- Development of a better understanding of O&M documentation needs for State operating staff
- Information more readily passed to retrocommissioning staff

14.1.3. Disadvantages

- High DGS billing rates to projects
- Less flexibility in responding to changing workload
- Challenge of recruiting and retaining staff
- Competition with private sector for staff
- Expense of training/continuing education

14.2. In-house Commissioning Project Managers

The use of in-house commissioning project managers is an alternative to DGS staff providing direct commissioning authority services. Under this alternative, regional commissioning managers would be responsible for overseeing the work of third-party commissioning contractors. These managers would develop an in-depth understanding of the commissioning process and would also develop relationships with regional commissioning providers. It is likely that two regional managers would be able to handle the workload.

14.2.1. Cost Issues

The cost of the in-house commissioning project managers may be partially offset by less time required from the Project Director to manage third-party commissioning contractors.

14.2.2. Advantages

- Fewer DGS staff required
- Can maintain some consistency in approach
- Develop in-house commissioning process expertise, serve as knowledge resource
- Potential to regionalize knowledge base

14.2.3. Disadvantages

- Contracting time and expense
- Less control over staff assignments within third-party contracting firms

14.3. Third-Party Contractor Commissioning

Under this approach DGS would continue to use third-party contractors to provide commissioning services. DGS project directors would oversee the work of the commissioning contractors.

14.3.1. Cost Issues

The hourly billing rates for third-party commissioning contractors is likely to be lower, on average, than the $163 per hour rate that might be charged to a project for in-house staff. However, contracting and administration costs may be higher than when using in-house commissioning staff.

14.3.2. Advantages

- Greater flexibility to handle varying project load
- Third-party contractors may have larger staff for greater scheduling flexibility
- Potentially lower cost to projects if contractor billing rates are lower than DGS rates
- Expertise for specialized buildings such as laboratories or data centers

14.3.3. Disadvantages

- Contracting time and expense
- Harder to control quality of services
- Likely to find significant variability in approach to commissioning between third-party contractors
- Little control over staff assignments within third-party contracting firms
- Retain less project knowledge over life of building
- Need to maintain third-party contract through the project warranty period

15.0 Conclusions and Recommendations

As noted in the previous section of this report, there are significant potential benefits to developing in-house DGS commissioning expertise *Perhaps the greatest benefits are retained knowledge, consistent application of methods, and better access to that expertise throughout the life of the building from design to operation and maintenance.* These benefits will be explored in much greater detail in subsequent tasks in this project.

Probably the most significant disadvantages to using in-house commissioning authorities are the ability to respond quickly to changes in workload (i.e. quickly adding or subtracting staff) and the relatively high hourly billing rate that DGS staff charges to projects.

An obvious solution to the issue of varying workload is to rely on third-party commissioning contractors to handle peaks in workload when in-house commissioning authorities are busy. Regardless, it is likely third-party commissioning contractors will be needed for specific expertise on some projects.

The analysis presented in Section 13.0 shows that about five commissioning authorities would be required to handle the current workload. It is not clear from this simple analysis what minimum base load of commissioning work would always be present, but it seems likely that at least three commissioning authorities could be busy full time. Those three could be supplemented by third-party contractors as needed.

If several in-house commissioning staff are hired, then obtaining a diversity of skills would be beneficial. It is unlikely that one person will have all the knowledge and skills desired in a commissioning authority. Therefore, the team can benefit if individual members have expertise in areas such as controls, HVAC, plumbing, and electrical systems. It is envisioned that DGS personnel from: 1) the Design Services Section (DSS) and Construction Services Section (CSS) of the Professional Services Branch (PSB) and 2) The Building Property Management Branch (BPM) will serve key roles in in-house Commissioning at DGS.

The salary level for commissioning authorities working in the private sector appears to be in-line with the DGS classifications of Construction Supervisor II ($81,444 to $99,000), Senior Mechanical Engineer ($88,452 to 107,460), or Construction Supervisor III ($97,164 to $118,104). See Section 12.2 for more information.

While each project needs an experienced commissioning authority, some commissioning tasks can be performed by a junior engineer under direction of the commissioning authority. As a rough estimate, about 20% of the commissioning work on a typical project can be performed by someone at a lower salary level. Therefore, after the State hires a few commissioning authorities, the team's capacity could be extended by adding a junior staff member. This approach could lower the overall cost to the State of providing commissioning services and provides a career path for junior staff members.

The alterative approach of using DGS commissioning project managers rather than commissioning authorities (as described in the previous section) can also be successful. This

approach offers the primary benefit of requiring fewer additional DGS staff, and the project management skills required for the role are familiar to DGS. This approach also helps retain some commissioning knowledge within DGS, although not to the same extent as the commissioning authority approach.

Integrating Building Commissioning into State Building Construction

Appendix A: Example DGS Duty Statements

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016

Arnold Schwarzenegger, *Governor*

Subtask 2 Deliverable

1.0 Construction Services Section (CSS) of PSB

STATE OF CALIFORNIA DEPARTMENT OF GENERAL SERVICES

DUTY STATEMENT

GS 907T (REV. 04/02)

SHADED AREA FOR HUMAN RESOURCES ONLY

INSTRUCTIONS: Refer to the Payroll and Personnel Procedures Manual (PPPM) for Duty Statement Instructions.

RPA- **003619**	EFFECTIVE DATE:

1. DGS OFFICE OR CLIENT AGENCY Real Estate Services Division	POSITION NUMBER (Agency - Unit - Class - Serial) - - -
2. UNIT NAME AND CITY LOCATED Construction Services Branch - Headquarters	3. CLASS TITLE Senior Mechanical Engineer
4. WORKING HOURS/SCHEDULE TO BE WORKED 7:00 a.m. to 3:30 p.m.	5. SPECIFIC LOCATION ASSIGNED TO Sacramento
	7. CURRENT POSITION NUMBER (Agency - Unit - Class - Serial) 719-601-3579-001

YOU ARE A VALUED MEMBER OF THE DEPARTMENT'S TEAM. YOU ARE EXPECTED TO WORK COOPERATIVELY WITH TEAM MEMBERS AND OTHERS TO ENABLE THE DEPARTMENT TO PROVIDE THE HIGHEST LEVEL OF SERVICE POSSIBLE. YOUR CREATIVITY AND PRODUCTIVITY ARE ENCOURAGED. YOUR EFFORTS TO TREAT OTHERS FAIRLY, HONESTLY AND WITH RESPECT ARE IMPORTANT TO EVERYONE WHO WORKS WITH YOU.

8. BRIEFLY (1 - 3 sentences) DESCRIBE THE POSITION'S ORGANIZATIONAL SETTING AND MAJOR FUNCTIONS

Under the general direction of the Chief, Construction Services Branch the Senior Mechanical Engineer oversees the inspection and commissioning of all mechanical construction work; performs the more difficult inspecton work and consults with design mechanical engineers on design and field problems; provide oversight of mechanical inspectors assigned to major new construction sites as well as inspectors in the four geographical districts. Typical duties include:

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
20%	The incumbent may be assigned to a large project site or various smaller sites and may need to travel throughout the entire geographical area of California performing mechanical inspection duties. All work is to be accomplished in accordance with guidelines of the Department of General Services (DGS), Real Estate Services Division policies and procedures, Construction Services Branch (CSB) Policy and Procedures Manual, California Code of Regulations, Title 24, the California Building Standards Codes, and the building industry standards. **ESSENTIAL FUNCTIONS** Performs inspection and testing of mechanical systems and oversight of mechanical construction contractors for projects statewide, including HVAC, fire sprinkler systems, emergency generation, building and process piping systems, pump plants, plumbing and elevators in order to assure contract and code compliance through interpretation of and in accordance with project plans and specifications. Reports on construction work in progress in order to inform the client agencies, RESD entities, and other governmental agencies of the project status through verbal and written techniques and in accordance with CSB policies and procedures and construction management tools and techniques. Prepares reports on inspections and submits to project and area construction supervisors in order to document work as completed during the construction phase utilizing written notes or a laptop computer to prepare the daily diaries and various reports following CSB policy and procedures.

11. SUPERVISOR'S STATEMENT: ***I HAVE DISCUSSED THE DUTIES OF THE POSITION WITH THE EMPLOYEE***

SUPERVISOR'S NAME (Print)	SUPERVISOR'S SIGNATURE	DATE

12. EMPLOYEE'S STATEMENT: ***I HAVE DISCUSSED WITH MY SUPERVISOR THE DUTIES OF THE POSITION AND HAVE RECEIVED A COPY OF THE DUTY STATEMENT***

The statements contained in this duty statement reflect general details as necessary to describe the principal functions of this job. It should not be considered an all-inclusive listing of work requirements. Individuals may perform other duties as assigned, including work in other functional areas to cover absence of relief, to equalize peak work periods or otherwise to balance the workload.

EMPLOYEE'S NAME (Print)	EMPLOYEE'S SIGNATURE	DATE

DUTY STATEMENT

GS 907T (REV. 1/98)

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
20%	In order to provide oversight of mechanical inspection effort at large projects including new prison construction and state office buildings following CSB guidelines • Sets procedures, testing and acceptance criteria by site visitation. • Checks the performance of mechanical inspectors by observation of their work and review of their daily written documentation. • Resolves complex mechanical design and/or field problems by review of written documents, site visits, and meeting with various entities i.e. project manager, Fire Marshall, OSHPD, contractors etc.
20%	In order to oversee the mechanical inspection effort in the geographical districts following CSB policies and procedures: • Prepares technical training plan for mechanical inspectors through written and verbal instructions i.e. training classes, memos, code changes, etc. • Provides technical guidance to mechanical inspectors through verbal and written direction i.e. one-on-one training, memos, e-mails etc. • Prepares various reports (project progress reports, report of complex mechanical field problems etc.) for the Area Supervisor, Chief and/or Assistant Chief of Construction Services Branch utilizing e-mails, laptop, power point presentations, and digital camera photos.
20%	Provides oversight of commissioning provided by independent commissioning consultants and the supervision of small commissioning performed by all mechanical inspectors statewide in order to verify that the facility performs to the requirements of the construction documents as they were designed in accordance with the codes and building standards, the utility district or energy standard requirements.
10%	Consults with Design Engineer, Area Construction Supervisor, and the Chief and/or Assistant Chief of Construction Services Branch on mechanical construction problems, procedures, methods, or materials that have statewide or program-wide consequences in order to resolve complex mechanical problems and/or field problems utilizing written and verbal communications, e-mails, laptops, specialized mechanical software and various equipment such as digital recorders, air hoods, sound meters, CFM meters, test gauges, etc.
05%	Drives a vehicle on large sites, from one site to another, and from one area to another area within the state in order to supervise and coordinate the inspection of the work through the use of a personal or state vehicle as directed by Construction Services Section management.

DUTY STATEMENT

GS 907T (REV. 1/98)

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
05%	**MARGINAL FUNCTIONS** • Initiates change orders for the project in order to make revisions to the original contract by submitting a Change Order Request in accordance with the Construction Services Branch Policy and Procedure Manual. • Prepares monthly progress reports, progress payment estimates, close out packages and other written documentation relating to construction projects in order to communicate the status of the project(s) ongoing activities, progress schedule, the quality of the work and issues affecting the critical path through the use of specialized software (i.e. Microsoft Office XP) and internet use, as directed by Construction Services Section Policy and Procedures Manual. • Approves and monitors the contractors schedule in order to keep current on the progress through CPM analysis, other network analysis techniques, and in accordance with industry standards as needed. • Assumes responsibility for checks of measurements, lines, and level in order to assure contract compliance through the use of levels and measuring tapes at times that are appropriate to the construction schedule as needed. • Observes, performs and/or coordinates the taking of tests or sampling of materials in order to determine compliance of the installed materials with the contract through the use of various testing equipment in accordance with industry testing standards. • Regularly requires the lifting of materials and/or equipment over 50 pounds (i.e. air flow hoods and testing equipment) in order to accomplish the various inspection tasks utilizing proper safety methods in accordance with safety guidelines and office procedures. **KNOWLEDGE AND ABILITIES** *Knowledge of*: Design of plans, specifications, and estimates for heating, ventilating, air-conditioning, refrigeration, plumbing, sanitary, water, water purification and drainage systems, and steam generating plants in common use; hydraulics pertaining to the design of water systems, pressure tanks, sewer systems, and other similar installations; various codes and safety orders and regulations governing the design and installation of mechanical equipment, including electric motors; materials and maintenance costs in connection with mechanical installations; electrical engineering as applied to motors in connection with air-conditioning, refrigeration, and blower systems; principles of effective supervision; department's Equal Employment Opportunity Program objectives; a manager's role in the Equal Employment Opportunity Program and the processes available to meet equal opportunity objectives. *Ability to*: Supervise the preparation of plans, specifications, and estimates for heating, ventilating, air-conditioning, refrigeration, plumbing, sanitary, water, water purification and drainage systems, and steam generating plants in common use; plan and supervise the work of others; make field inspections and surveys and prepare reports and recommendations; direct or inspect field construction operations; check drawings and specifications; establish and maintain cooperative relations with those contacted in the work; analyze situations accurately and adopt an effective course of action; dictate correspondence and prepares reports; effectively contribute to the department's equal employment objectives.

DUTY STATEMENT

GS 907T (REV. 1/98)

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
	SPECIAL PERSONAL CHARACTERISTICS Tact; keenness of observation; and physical stamina. **DESIRABLE QUALIFICATIONS** ADDITIONAL QUALIFICATIONS • Possession of a valid California Drivers License (Class C) • Possession of a certificate in mechanical construction, inspection, or code enforcement from the: International Association of Plumbing and Mechanical Officials (IAPMO) or similar association or regulatory governmental organization; • Apply your knowledge of Title 24, the California Building Standards Code, NFPA standard specifications, plans and test methods • Current registration as an engineer (mechanical) • Proficiency with MS Office (Word and Excel) INTERPERSONAL SKILLS • Work well with a team and independently • Build good working relationships with contractors and clients **WORK ENVIRONMENT, PHYSICAL OR MENTAL ABILITIES** • Walk on uneven ground and around objects/materials scattered on the ground. • Climb ladders or ships ladders. • Ability to move the neck in an unrestricted manner from the front to back and from side to side in order to perform duties. • Reaching by extending hand(s), arms(s) and foot/feet in any direction. • Manipulate small components and controls using fine motor skills/manual dexterity. • Visually inspect construction sites and workmanship. • Hear within normal range for safety purposes in a construction area. • Work in a noisy, vibration, dusty, machinery filled environment typical of a construction site. • Walk or stand for extended periods of time. • Work in inclement weather conditions. • Work in prison facilities and around in-mates. • Travel and work overtime as needed. • Daily use of a personal computer and/or laptop and related software applications. • Bend, stoop, kneel and lift 50 lbs. • Use a digital camera. • Sit for extended periods of time driving from project site to project site. • Carry a cell phone.

The CSS would be helpful in a Cx team within DGS to lend technical knowledge and field savvy to the Cx process.

2.0 Design Services Section (DSS) of PSB

**** Note: Duty statement to be added here.

The DSS is mainly involved with building projects below $50,000, and thus does not typically engage in large-scale, design-build projects as with the Caltrans building in Marysville. However, DSS can play a critical role in the Cx process for large-scale projects by serving in a design review capacity. For smaller scale projects that are designed within DSS, Cx design review can be performed independently by DSS colleagues who were not involved with a given design. The Cx Toolkit for Small Projects would be useful for this purpose.

3.0 Building Property Management Branch (BPM)

The duty statements of facilities personnel in the PMB suggest a significant, broad set of technical knowledge and skills to augment direct field experience. This would prove invaluable in Cx activities.

4.0 Maintenance Mechanic

STATE OF CALIFORNIA DEPARTMENT OF GENERAL SERVICES

DUTY STATEMENT

GS 907T (REV. 04/02)

SHADED AREA FOR HUMAN RESOURCES ONLY

INSTRUCTIONS: Refer to the Payroll and Personnel Procedures Manual (PPPM) for Duty Statement Instructions.

RPA- -	EFFECTIVE DATE:

1. DGS OFFICE OR CLIENT AGENCY Building and Property Management	POSITION NUMBER (Agency - Unit - Class - Serial) - - -
2. UNIT NAME AND CITY LOCATED CalTrans District 3 Headquarters, Marysville	3. CLASS TITLE Maintenance Mechanic
4. WORKING HOURS/SCHEDULE TO BE WORKED 8:00 a.m. to 5:00 p.m. Monday through Friday	5. SPECIFIC LOCATION ASSIGNED TO 703 B. Street, Marysville, CA 95901
6. PROPOSED INCUMBENT (If known)	7. CURRENT POSITION NUMBER (Agency - Unit - Class - Serial) ???-???-6940-XXX

YOU ARE A VALUED MEMBER OF THE DEPARTMENT'S TEAM. YOU ARE EXPECTED TO WORK COOPERATIVELY WITH TEAM MEMBERS AND OTHERS TO ENABLE THE DEPARTMENT TO PROVIDE THE HIGHEST LEVEL OF SERVICE POSSIBLE. YOUR CREATIVITY AND PRODUCTIVITY ARE ENCOURAGED. YOUR EFFORTS TO TREAT OTHERS FAIRLY, HONESTLY AND WITH RESPECT ARE IMPORTANT TO EVERYONE WHO WORKS WITH YOU.

8. BRIEFLY (1 or 2 sentences) DESCRIBE THE POSITION'S ORGANIZATIONAL SETTING AND MAJOR FUNCTIONS

Under the general direction of the Supervisor of Building Trades or Chief Engineer, the incumbent performs miscellaneous skilled work in the maintenance, repair and alteration of multiple facilities in State owned and occupied buildings within the region working independently in a wide variety of skilled maintenance tasks.

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
20%	The CalTrans District 3 Headquarters, located in Marysville, California, is an innovative five story office structure comprising approximately 210,000 square feet. The incumbent applies sustainable (environmentally safe) work practices in the operation and maintenance of all building systems and equipment. All work to be accomplished in accordance with guidelines of the Department of General Services (DGS), Building and Property Management (BPM) Manuals, Real Estate Services Division (RESD) and BPM strategic plans, and the Excellence in Public Buildings Initiative in order to maintain and repair building systems, following published guidelines (i.e., SAM, BPM, DGS) and published industry standards (i.e., BOMA, ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), SMACNA (Sheet Metal and Air Conditioning Contractor's National Association), IEEE (Institute of Electrical and Electronic Engineers), NEI (National Energy Institute). Assignment may require temporary shift change or building location change. **ESSENTIAL FUNCTIONS** In order to maintain and repair all building systems following published guidelines and industry standards. • Completes building tours by visual inspection of all building systems and equipment requiring walking, climbing stairs, entering small spaces and noisy spaces. • Records findings in manual building tour log.

11. SUPERVISOR'S STATEMENT: ***I HAVE DISCUSSED THE DUTIES OF THE POSITION WITH THE EMPLOYEE***

SUPERVISOR'S NAME (Print)	SUPERVISOR'S SIGNATURE	DATE

12. EMPLOYEE'S STATEMENT: ***I HAVE DISCUSSED WITH MY SUPERVISOR THE DUTIES OF THE POSITION AND HAVE RECEIVED A COPY OF THE DUTY STATEMENT***

The statements contained in this duty statement reflect general details as necessary to describe the principal functions of this job. It should not be considered an all-inclusive listing of work requirements. Individuals may perform other duties as assigned, including work in other functional areas to cover absence of relief, to equalize peak work periods or otherwise to balance the workload.

EMPLOYEE'S NAME (Print)	EMPLOYEE'S SIGNATURE	DATE

DUTY STATEMENT

GS 907T (REV. 1/98)

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
20%	• Recommends and takes appropriate action on repairs by evaluating functionality of equipment and systems. Constructs and repairs interior/exterior walls by patching, matching finishes, and painting as required. Responds to service requests as submitted by tenants or other BPM staff by following BPM guidelines and warranty requirements and reports to supervisor when appropriate. • Responds and effects repairs to office comfort calls and common area calls as needed, by going to the physical site and repairing electrical outlets, replacing lights, adjusting mechanical and/or electrical doors, fixing leaky sinks, clearing stuck flush valves, unplugging toilets and performing other simple and/or routine repair, comfort and convenient needs. • Responds to emergency calls in order to mitigate emergency conditions and minimize damage by performing repair at physical location according to health and safety and BPM guidelines regarding emergency situations. This may require working after hours, on days off or at another building location. • Orders parts and makes recommendations on more complex repairs when unable to complete service or repair requests and follows action through to completion. • Reads and analyzes blueprints and specifications in order to understand and provide information on system problems in accordance with design parameters.
20%	In order to maintain integrity and functionality to ensure reliability and long-term use of building, related systems and machinery used to maintain buildings, shops and grounds (various vacuums, blowers, grinders, electrical cords, sharpening tools, moving parts on office furnishing, etc.) as directed by the Supervisor of Building Trades or Chief Engineer following published guidelines, manufacturer's specifications and industry standards. Using appropriate hand and/or power tools: • Installs, inspects, maintains, repairs, troubleshoots or assists engineers, electricians, electronic technicians all building systems, including but not limited to power distribution systems, plumbing and sewer systems, domestic water pump stations, fire sprinkler systems, doors and related components, lighting fixtures, and ceiling components, maintains parking lot lighting, controls, gate operators, etc. • Repairs interior/exterior concrete surfaces and steps. • Makes simple furniture repairs. • Constructs and repairs interior/exterior walls by patching, matching finishes, and painting as required. • Makes or assists with repairs to roofing systems, (i.e., rubber, asphalt, single ply membrane) in accordance with manufacturers' guidelines. • Repairs/installs various types of floor coverings, including carpet tiles, VCT, and ceramic tiles.
15%	In accordance with direction from BPM supervisors or lead workers, monitors work on all building systems following published guidelines and industry standards. Using Microsoft Office and/or Maximo: • Tracks warranties and accurately records status by making detailed notes. • Prepares correspondence to contractors regarding 'notices to correct'. • Monitors service contracts and inspects work for quality. • Tracks and reviews all building systems permits. • Updates work order tickets in MAXIMO or MS Office.

10%	In order to maintain a safe and healthful environment for the benefit of all employees and the public, under direction of the Supervisor of Building Trades or Chief Engineer and BPM Environmental Safety and Health Unit (ESHOP), in compliance with laws and regulations, the Occupational Safety and Health Administration (OSHA), Safety Training (AB 2189), Injury and Illness Prevention (IIPP and SB 298), Workers' Compensation (Title 8 and SB 198), by promoting health and safety programs as follows: • Attends training in the handling of hazardous materials and use of environmental safeguards. • Participates in updating IIPP plans and records by completing reports and coordinating with the designated Branch Coordinator. • Participates in and/or leads team in executing the plans for Emergency Response, Disaster Recovery and Business Resumption, and Hazardous Materials and Waste Manifest.
10%	Organizes and maintains records, files and technical listings on equipment, tools and products using Microsoft Office and/or Maximo in order to make recommendations on recurring maintenance, special repairs, equipment, tools and supply prices to the BPM budget in accordance with DGS and DOF guidelines.
5%	**MARGINAL FUNCTIONS** • Makes reports in Microsoft Office, Maximo or by manual reporting in order to report and track completed work per BPM procedures. • Acts as backup Maintenance Mechanic, as directed by BPM managers or supervisors, at any regional facility, in order to assure continuous and efficient operations of all buildings systems and equipment. • Attends current BPM training classes to maintain ethical work standards as directed by BPM managers and supervisors. • Assists supervisor, as needed, using current records programs (Microsoft Office, Maximo) and communicating with building staff in person or via cellular telephone, 2-way radio, or other electronic devices in order to facilitate building maintenance needs and take appropriate action in accordance with BPM guidelines. • Serves as Unit Safety Coordinator in order to do thorough routine inspections of all state owned buildings for compliance with janitorial safety requirements. Prepares written status reports in order to report findings using Microsoft Office or manual report per BPM procedures and policies. • May attend with, lead, or instruct other BPM team members in on-going safety training conducted locally.
	KNOWLEDGE AND ABILITIES ***Knowledge of*:** Methods, materials, and equipment used in the operation and repair of plumbing, heating, electrical, water, and sewer systems; materials, methods, and tools used in the repair of mechanical equipment and in miscellaneous building maintenance and repair work and skill in the performance of such work; Safety Orders of the Division of Industrial Safety dealing with heating, electrical, plumbing, and other mechanical systems. ***Ability to:*** Read, interpret, and work from plans, drawings, and specifications; estimate materials needed; keep records; follow oral and written directions; get along well with others; read and write at a level appropriate to the classification.
	DESIRABLE QUALIFICATIONS SPECIAL PERSONAL CHARACTERISTICS • Demonstrates superior mechanical ability. • Demonstrates interest in assuming increasing responsibility. • Knowledge of Microsoft Word, Excel, Maximo, ABMS, PAL, and Outlook. INTERPERSONAL SKILLS • Ability to organize time efficiently and set effective priorities. • Uses good judgment and tact in making decisions and working with employees and interacting with clients.

	WORK ENVIRONMENT, PHYSICAL OR MENTAL ABILITIES • Office buildings ranging from single story to 4 stories in height. • Mechanical equipment spaces environments. • Wear unaltered BPM supplied shirts and pants according to current policy. • Ability to stand for extended periods of time or walk extended distances. • Ability to climb stairs and ladders. • Ability to reach or stretch by extending hand(s) or arm(s) in any direction. • Ability to bend, stoop and kneel. • Ability to lift up to 50 pounds. • Ability to move about and work in confined spaces. • Ability to reach high spaces by climbing a ladder or operating a lift. • Ability to work in noisy spaces. • Ability to see and hear within normal parameters. • Willingness to work in any regional location. • May require valid California Driver's License, Class C. • May require ability to work overtime. • Requires fine motor skills/dexterity to manipulate small components and controls. • May work outdoors in various weather conditions • May require a Department of Justice security background check.

5.0 Chief Engineer II

STATE OF CALIFORNIA DEPARTMENT OF GENERAL SERVICES

DUTY STATEMENT

GS 907T (REV. 04/02)

SHADED AREA FOR HUMAN RESOURCES ONLY

INSTRUCTIONS: Refer to the Payroll and Personnel Procedures Manual (PPPM) for Duty Statement Instructions.

RPA- **-BPM**	EFFECTIVE DATE:

1. DGS OFFICE OR CLIENT AGENCY Building And Property Management	POSITION NUMBER (Agency - Unit - Class - Serial) - - -
2. UNIT NAME AND CITY LOCATED CalTrans District 3/Marysville	3. CLASS TITLE Chief Engineer II
4. WORKING HOURS/SCHEDULE TO BE WORKED 8:00 a.m. to 5:00 p.m. Monday-Friday	5. SPECIFIC LOCATION ASSIGNED TO CalTrans District 3 Headquarters 703 B. Street, Marysville CA 95901
6. PROPOSED INCUMBENT (If known)	7. CURRENT POSITION NUMBER (Agency - Unit - Class - Serial) ???-???-6695-XXX

YOU ARE A VALUED MEMBER OF THE DEPARTMENT'S TEAM. YOU ARE EXPECTED TO WORK COOPERATIVELY WITH TEAM MEMBERS AND OTHERS TO ENABLE THE DEPARTMENT TO PROVIDE THE HIGHEST LEVEL OF SERVICE POSSIBLE. YOUR CREATIVITY AND PRODUCTIVITY ARE ENCOURAGED. YOUR EFFORTS TO TREAT OTHERS FAIRLY, HONESTLY AND WITH RESPECT ARE IMPORTANT TO EVERYONE WHO WORKS WITH YOU.

8. BRIEFLY (1 - 3 sentences) DESCRIBE THE POSITION'S ORGANIZATIONAL SETTING AND MAJOR FUNCTIONS

Under the supervision of the Building Manager II, the incumbent leads and works with others in the day-to-day operation, maintenance, and repair of the heating and electrical plant and other mechanical and power equipment of State owned and occupied buildings. Other related work may include administrative functions to assist Building Management.

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
DUTIES 10%	All work to be accomplished in accordance with guidelines of the Department of General Services (DGS), Building and Property Management (BPM) manuals, Real Estate Service Division (RESD) and BPM strategic plans, and the Excellence in Public Buildings Initiative. The incumbent directs and supervises the workload of staff, including skilled engineers, apprentices, maintenance mechanics, building maintenance workers and custodians, in order to maintain and repair all building systems following published guidelines (i.e., SAM, BPM, DGS) and published industry standards (i.e., BOMA, ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), SMACNA (Sheet Metal and Air Conditioning Contractor's National Association), IEEE (Institute of Electrical and Electronic Engineers), NEI (National Energy Institute). **ESSENTIAL FUNCTIONS** Monitors work on all building systems following published guidelines and industry standards. Using Microsoft Office and/or Maximo: • Tracks warranties and accurately records status by making detailed notes. • Prepares correspondence to contractors regarding 'notices to correct'. • Monitors service contracts and inspects work for quality. • Tracks and reviews all building systems permits. • Organizes and maintains equipment records, files and technical listings on equipment.

11. SUPERVISOR'S STATEMENT: ***I HAVE DISCUSSED THE DUTIES OF THE POSITION WITH THE EMPLOYEE***

SUPERVISOR'S NAME (Print)	SUPERVISOR'S SIGNATURE	DATE

12. EMPLOYEE'S STATEMENT: ***I HAVE DISCUSSED WITH MY SUPERVISOR THE DUTIES OF THE POSITION AND HAVE RECEIVED A COPY OF THE DUTY STATEMENT***

The statements contained in this duty statement reflect general details as necessary to describe the principal functions of this job. It should not be considered an all-inclusive listing of work requirements. Individuals may perform other duties as assigned, including work in other functional areas to cover absence of relief, to equalize peak work periods or otherwise to balance the workload.

EMPLOYEE'S NAME (Print)	EMPLOYEE'S SIGNATURE	DATE

DUTY STATEMENT

GS 907T (REV. 1/98)

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
20%	Maintains supply, products, tools and equipment inventories following Procurement, SAM, BPM, DGS guidelines and industry standards. • Determines supply, product, tool and equipment needs according to system specifications. • Gathers prices and makes comparisons using catalogs, the Internet, and vendor and supplier prices and estimates. • Recommends appropriate purchases according to comparisons. • Completes and submits requisition and obtains manager/supervisor approval as dictated by purchasing guidelines. • May assign staff or personally perform weekly inventory by doing a physical and visual shelf count. • Records or monitors inventory count in Microsoft Office and/or Maximo databases.
25%	In order to supervise employees following DGS guidelines and SPB/DPA laws and rules: • Plans, assigns and supervises work of skilled and semi-skilled workers engaged in the operation, maintenance and repair of heating ventilating, air conditioning, plumbing, electrical, Building Automated Control, mechanical and all other related building systems. • Plans assigns and supervises trades and crafts work in the operation, maintenance and repair of the facilities. • Administers special repairs and projects related to building operations and maintenance from installation to completion. • Ensures that facilities, equipment rooms, work areas, equipment and tools are operational, clean, orderly, and safe. • Assists with the management of the contract building security staff and systems.
20%	In order to prepare the budget, requisitions, contracts and reports in accordance with DGS/Financial guidelines and regulations: • Prepares requisitions including quoted and proposals for supplies, parts and additional labor necessary for the repair ad maintenance of the facilities' heating, ventilating, air conditioning, plumbing, electrical, and all other related systems. • Provides assistance in the preparation of contracts, including proposals to building management related to the operations and maintenance of the facilities in region IV. • Prepares reports related to the operations and maintenance of the facilities and maintains record keeping.
10%	In order to perform administration functions per Department Guidelines: • Performs personnel administration duties. Evaluates staff performance and recommend appropriate action including but not limited to merit salary adjustments and progressive discipline. • Provides and performs training for staff members both technical and Departmental. Identify staff training needs through assessment based on facility operational and maintenance requirements.

10%	Investigates problems on behalf of the Office Building Manager, in Building Managers absence, resolves client/tenant complaints regarding facility operations and maintenance issues. In order to maintain an accurate reporting to the State Controllers Office (SCO) for issuance of correct payroll warrants or subordinate staff's time or accurate reporting to the Office of Fiscal Services (OFS) for the billing of services for clients through the use of the Project Accounting & Leave (PAL) system in accordance with DGS policies and guidelines, MOU provision and SPB or DPA laws and rules. • Grants or denies subordinate staff request for time off or request to work overtime. • Ensures subordinate staff has sufficient leave credits available for the leave requested. • Approves PAL entries for subordinate staff on dock or AWOL on or before the designated SCO semi-monthly or monthly payroll cut-off date to ensure the correct issuance of an SCO warrant for pay day. • Approves or disapproves PAL entries for subordinate staff within three working days after the completion of the pay period to ensure the correct issuance of an SCO warrant (when returned to SCO for late dock), issuance of correct overtime pay, and proper billing to clients for services rendered.
5%	**MARGINAL DUTIES** Acts as backup in the absence of the Building Manager II or III, as directed by BPM managers, in order to assure continuous and efficient operations of all building systems and equipment. Support duties include communicating with building staff in person or via cellular telephone, 2-way radio, or other electronic devices, and taking appropriate action in response to service needs.
	KNOWLEDGE AND ABILITIES Knowledge of: • Heating, ventilating, refrigeration, air-conditioning, Building Automated Control Systems, electrical, water, sewage, elevator, and other mechanical systems, and the methods, materials, and tools used in their operation, maintenance, and repair; • Safety Orders of the California Division of Occupational Safety and Health applying to heating, electrical, and other related mechanical equipment. • Analysis and treatment of water treatment. • Principals of effective supervision. • Department's Equal opportunity program objectives. Ability to: • Read and write English at a level required for successful job performance. • Direct the work of installing, operating, and maintaining heating, ventilating, refrigeration, and air-conditioning, Building Automated Control and all other building related systems. • Lead the work of skilled craftsmen and semiskilled workers and keep accurate records. • Prepare reports and act quickly in emergencies.
	ADDITIONAL QUALIFICATIONS • Education equivalent to completion of the twelfth grade. • Possess a valid California driver's license. • Possess universal CFC certificate • Be experienced in CFC evacuation, charging and record keeping.
	INTERPERSONAL SKILLS • Ability to maintain required and/or flexibility in assignments and regional locations • Ability to organize time efficiently and set effective priorities. • Ability to display good interaction skills.

	SPECIAL PERSONAL CHARACTERISTICS • Office buildings ranging from single story to high-rise (10 floors and above), and • Education equivalent to completion of the twelfth grade. • Requires willingness to work in any regional location. • May require ability to work overtime. • May be required to work weekends. • Education equivalent to completion of the twelfth grade. • Must possess a valid California Driver's License. • May require ability to work overtime.
	WORK ENVIRONMENT, PHYSICAL OR MENTAL ABILITIES • Ability to stand for extended periods of time or walk extended distances, • Ability to climb stairs and ladders, • Ability to reach or stretch by extending hand(s) or arm(s) in any direction, • Ability to bend, stoop and kneel • Ability to lift up to 50 pounds. • Ability to move about and work in confined spaces, • Ability to reach high spaces by climbing • Office buildings ranging from single story to high-rise (10 floors and above), and • Mechanical equipment spaces environments.

6.0 Stationary Engineer

STATE OF CALIFORNIA DEPARTMENT OF GENERAL SERVICES

DUTY STATEMENT

GS 907T (REV. 04/02)

SHADED AREA FOR HUMAN RESOURCES ONLY

INSTRUCTIONS: Refer to the Payroll and Personnel Procedures Manual (PPPM) for Duty Statement Instructions.

RPA-	EFFECTIVE DATE:

1. DGS OFFICE OR CLIENT AGENCY Department of General Services	POSITION NUMBER (Agency - Unit - Class - Serial) - - -
2. UNIT NAME AND CITY LOCATED CalTrans District 3 Headquarters, Marysville	3. CLASS TITLE Stationary Engineer
4. WORKING HOURS/SCHEDULE TO BE WORKED 8:00 a.m. to 5:00 p.m. Monday through Friday	5. SPECIFIC LOCATION ASSIGNED TO 703 B. Street, Marysville, CA 95901
6. PROPOSED INCUMBENT (If known)	7. CURRENT POSITION NUMBER (Agency - Unit - Class - Serial) ???-???-6712-???

YOU ARE A VALUED MEMBER OF THE DEPARTMENT'S TEAM. YOU ARE EXPECTED TO WORK COOPERATIVELY WITH TEAM MEMBERS AND OTHERS TO ENABLE THE DEPARTMENT TO PROVIDE THE HIGHEST LEVEL OF SERVICE POSSIBLE. YOUR CREATIVITY AND PRODUCTIVITY ARE ENCOURAGED. YOUR EFFORTS TO TREAT OTHERS FAIRLY, HONESTLY AND WITH RESPECT ARE IMPORTANT TO EVERYONE WHO WORKS WITH YOU.

8. BRIEFLY (1 - 3 sentences) DESCRIBE THE POSITION'S ORGANIZATIONAL SETTING AND MAJOR FUNCTIONS

Under general direction from the Chief Engineer or Building Manager, the incumbent performs a variety of skilled work in the operation, maintenance and repair of boiler, heating, air conditioning, ventilating, lighting, power, water, water treatment, security systems and other mechanical systems normally found in office buildings or a complex of buildings.

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
25%	The CalTrans District 3 Headquarters, located in Marysville, California, is an innovative five story office structure comprising approximately 210,000 square feet. The incumbent applies sustainable (environmentally safe) work practices in the operation and maintenance of all building systems and equipment. All work to be accomplished in accordance with guidelines of the Department of General Services (DGS), Building and Property Management (BPM) manuals, Real Estate Service Division (RESD) and BPM strategic plans, and the Excellence in Public Buildings Initiative in order to maintain and repair all building systems following published guidelines (i.e., SAM, BPM, DGS) and published industry standards (i.e., BOMA, ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), SMACNA (Sheet Metal and Air Conditioning Contractor's National Association), IEEE (Institute of Electrical and Electronic Engineers), NEI (National Energy Institute). Assignment may require temporary shift change or building location change. **ESSENTIAL FUNCTIONS** In order to maintain and repair all building systems following published guidelines and industry standards. • Completes watch tours by visual inspection of all building systems and equipment requiring walking, climbing stairs, entering small spaces and noisy spaces. • Records findings in manual watch tour log. • Recommends and takes appropriate action on repairs by evaluating functionality of equipment and systems. • Calibrates and repairs automated building systems by physically aligning setting within design parameters. • Programs automated building systems through software application (i.e., Allerton). • Administers and organizes files and database by backing up files and debugging database.

11. SUPERVISOR'S STATEMENT: ***I HAVE DISCUSSED THE DUTIES OF THE POSITION WITH THE EMPLOYEE***

SUPERVISOR'S NAME (Print)	SUPERVISOR'S SIGNATURE	DATE

12. EMPLOYEE'S STATEMENT: ***I HAVE DISCUSSED WITH MY SUPERVISOR THE DUTIES OF THE POSITION AND HAVE RECEIVED A COPY OF THE DUTY STATEMENT***

The statements contained in this duty statement reflect general details as necessary to describe the principal functions of this job. It should not be considered an all-inclusive listing of work requirements. Individuals may perform other duties as assigned, including work in other functional areas to cover absence of relief, to equalize peak work periods or otherwise to balance the workload.

EMPLOYEE'S NAME (Print)	EMPLOYEE'S SIGNATURE	DATE

DUTY STATEMENT

GS 907T (REV. 1/98)

9. Percentage of time performing duties	10. Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
25%	Responds to service requests as submitted by tenants or other BPM staff by following BPM guidelines and warranty requirements and reports to supervisor when appropriate. • Responds and effects repairs to office comfort calls and common area calls as needed, by going to the physical site and adjusting thermostats, repairing electrical outlets, replacing lights, adjusting mechanical and/or electrical doors, fixing leaky sinks, clearing stuck flush valves, unplugging toilets and performing other simple and/or routine repair, comfort and convenience needs. • Responds to emergency calls in order to mitigate emergency conditions and minimize damage by performing repair at physical location according to health and safety and BPM guidelines regarding emergency situations. This may require working after hours, on days off or at another building location. • Orders parts and makes recommendations on more complex repairs when unable to complete service or repair requests and follows action through to completion. • Reads and analyzes blueprints and specifications in order to understand and provide information on system problems in accordance with design parameters.
15%	In order to maintain a safe and healthful environment for the benefit of all employees and the public, under direction of the Chief Engineer II and BPM Environmental Safety and Health Unit (ESHOP), in compliance with laws and regulations, the Occupational Safety and Health Administration (OSHA), Safety Training (AB 2189), Injury and Illness Prevention (IIPP and SB 298), Workers' Compensation (Title 8 and SB 198), by promoting the health and safety programs as follows: • Attends training in the handling of hazardous materials and use of environmental safeguards. • Participates in updating IIPP plans and records by completing reports and coordinating with the designated Branch coordinator. • Participates in and/or leads team in executing the plans for Emergency Response, Disaster Recovery and Business Resumption, and Hazardous Materials and Waste Manifest.
10%	In accordance with direction from BPM supervisors or lead workers, monitors work on all building systems following published guidelines and industry standards. Using Microsoft Office and/or Maximo: • Tracks warranties and accurately records status by making detailed notes. • Prepares correspondence to contractors regarding 'notices to correct'. • Monitors service contracts and inspects work for quality. • Tracks and reviews all building systems permits.
10%	Organizes and maintains records, files and technical listings on equipment. Makes recommendations using recorded data on recurring maintenance, special repairs and equipment prices in order to provide input to BPM budget in accordance with DGS and DOF guidelines. Utilizes computer Maximo maintenance database and work order tracking system.
10%	Inspects and evaluates all building systems in order to minimize energy waste and promote energy conservation assuring proper operating procedures and system integration according to guidelines established by Cal EPA and California Energy Commission.
5%	**MARGINAL FUNCTIONS** May act as backup stationary engineer, as directed by BPM managers or supervisors, at any regional facility, in order to assure continuous and efficient operations of all building systems and equipment. Support duties include communicating with building staff in person or via cellular telephone, 2-way radio, or other electronic devices, and taking appropriate action in response to service needs. May instruct or lead other engineers. May attend with, lead, or instruct other BPM team members in on-going safety training conducted locally.

KNOWLEDGE AND ABILITIES

Knowledge of: Boilers and auxiliary boiler room equipment; heating, lighting, ventilating, air conditioning, power, refrigeration, building electric and pneumatic controls, water treatment and other mechanical or electrical equipment; building security systems; the methods, tools, materials, and equipment used in the operation, maintenance and repair of such equipment.

Ability to: Follow oral and written directions; demonstrate mechanical ability; keep accurate records; install, operate and make repairs to the various types of equipment listed above in the knowledge requirements; make written reports, read, interpret, and work from plans, drawings and specifications; lay out work for others and direct them in this work; analyze situations accurately and take effective action.

DESIRABLE QUALIFICATIONS

ADDITIONAL QUALIFICATIONS**:**

- Possess a universal CFC certificate.
- Be experienced in CFC evacuation, charging and record keeping.
- Education equivalent to completion of the twelfth grade.

INTERPERSONAL SKILLS

- Organize time efficiently and set effective priorities.
- Display good interaction skills.

WORK ENVIRONMENT, PHYSICAL OR MENTAL ABILITIES

- Office buildings ranging from single story to 4 stories in height
- Mechanical equipment spaces.
- Wear unaltered BPM supplied shirts and pants according to current policy.
- Stand for extended periods of time or walk extended distances.
- Climb stairs and ladders.
- Reach or stretch by extending hand(s) or arm(s) in any direction.
- Bend, stoop and kneel.
- Lift up to 50 pounds.
- Move about and work in confined spaces.
- Reach high spaces by climbing a ladder or operating a lift.
- Work in noisy spaces.
- See and hear within normal parameters.
- Willingness to work in any regional location.
- May require valid California Driver's License, Class C.
- May require ability to work overtime.
- May require a Department of Justice security background check.

7.0 Office Building Manager II

STATE OF CALIFORNIA DEPARTMENT OF GENERAL SERVICES

DUTY STATEMENT

GS 907T (REV. 08/01) *SHADED AREA TO REFLECT RECLASS POSITION NUMBER ONLY*

INSTRUCTIONS: Refer to the Essential Functions Duty Statement Manual for instructions on how to complete the Duty Statement.	RPA- **00????-BPM**	EFFECTIVE DATE:

DGS OFFICE OR CLIENT AGENCY Building and Property Management	POSITION NUMBER (Agency - Unit - Class - Serial) - - -
UNIT NAME AND CITY LOCATED Region ??? – CalTrans District 3 Marysville, CA	CLASS TITLE Office Building Manager II
WORKING DAYS AND WORKING HOURS Monday through Friday 8:00 a.m. to 5:00 p.m.	SPECIFIC LOCATION ASSIGNED TO 703 B. Street, Marysville, CA 95901
PROPOSED INCUMBENT (If known)	CURRENT POSITION NUMBER (Agency - Unit - Class - Serial) ???-???-6672-???

YOU ARE A VALUED MEMBER OF THE DEPARTMENT'S TEAM. YOU ARE EXPECTED TO WORK COOPERATIVELY WITH TEAM MEMBERS AND OTHERS TO ENABLE THE DEPARTMENT TO PROVIDE THE HIGHEST LEVEL OF SERVICE POSSIBLE. YOUR CREATIVITY AND PRODUCTIVITY ARE ENCOURAGED. YOUR EFFORTS TO TREAT OTHERS FAIRLY, HONESTLY AND WITH RESPECT ARE IMPORTANT TO EVERYONE WHO WORKS WITH YOU.

BRIEFLY (1 or 2 sentences) DESCRIBE THE POSITION'S ORGANIZATIONAL SETTING AND MAJOR FUNCTIONS

Under the direction of the Regional Manager and the Office Building Manager III, the incumbent leads and directs the work of others engaged in the day-to-day operations, maintenance, repair, and cleaning of the Franchise Tax Board Building. The incumbent will perform all necessary duties to provide for the continued operation of the client located within and at this property requiring this incumbent to be able to walk around approximately 1.8 million gross square feet and 90 acres of property daily.

% of time performing duties	Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
	The CalTrans District 3 Headquarters facility is located at 703 B. Street in Marysville, Ca. It is an innovative 5 story facility having approximately 210,000 gross square feet. **DUTIES** The incumbent plans the work of support staff engaged in the maintenance, custodian operations, upkeep and other services for the State-owned and occupied building and grounds. The staff may include skilled crafts supervisors, stationary engineers, and custodian supervisors. The work is performed in order to maintain and repair all building systems in accordance with published guidelines as set forth in Sections 14600 through 14973 of the Government Code, the Department of General Services (DGS), Division of the State Architect (DSA) Excellence in Public Building Initiative, and the Building Owners and Managers Association (BOMA) industry standards. **Although normal business hours are 8:00 a.m.-5:00 p.m., incumbent may be called upon and expected to respond at any time of the day or night. BPM will provide incumbent with a cell phone for this purpose. Cell phone messages shall be returned promptly.** **This position is designated under the Conflict of Interest Code. The position is responsible for making, or participating in the making, of governmental decisions that may potentially have a material effect on personal financial interests. The appointee is required to complete form 700 within 30 days of appointment. Failure to comply with the Conflict of Interest Code requirements may void the appointment.**

SUPERVISOR'S STATEMENT: *I HAVE DISCUSSED THE DUTIES OF THE POSITION WITH THE EMPLOYEE*

SUPERVISOR'S NAME (Print)	SUPERVISOR'S SIGNATURE	DATE

EMPLOYEE'S STATEMENT: *I HAVE DISCUSSED WITH MY SUPERVISOR THE DUTIES OF THE POSITION AND HAVE RECEIVED A CO*

The statements contained in this duty statement reflect general details as necessary to describe the principal functions of this job. It should not be considered an all-inclusive listing of work requirements. Individuals may perform other duties as assigned, including work in other functional areas to cover absence of relief, to equalize peak work periods or otherwise balance the workload.

EMPLOYEE'S NAME (Print)	EMPLOYEE'S SIGNATURE	DATE

STATE OF CALIFORNIA DEPARTMENT OF GENERAL SERVICES

DUTY STATEMENT

GS 907T (REV. 03/05) **RPA 008766-BPM**

% of time performing duties	Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
35%	**ESSENTIAL FUNCTIONS** **Facility Operations and Maintenance** The Office Building Manager II will provide customer service in directing guidelines to the subordinate staff following the DGS/RESD/DSA policies, strategic plans and manuals to ensure preservation of the state's investment. • Oversees Building and Property Management program services to maintain State owned buildings in order to deliver effective high quality services to occupant/customer. • Implement maintenance and repair services including but not limited to cleaning, grounds care, trades/crafts, security/guard, HVAC, automation systems, structural systems and interior finishes to ensure preservation of the State's investment. • Promotes and ensures customer satisfaction by overseeing service delivery to provide productive business environments for staff and occupants. • Prepares written operational plans for the buildings and its grounds to provide efficient and effective administrative, fiscal, engineering/trades, custodial and security programs. • Resolves operational problems related to the buildings and its grounds to maintain a healthy and safe environment for all staff, customers and the public. • Ensures delivery of construction warranties of new building(s) and related systems by formal and timely written notice to contractors when corrections are needed to ensure suitable operations of designed construction.
20%	**Budget Management** The Office Building Manager II assists in preparing the Units annual budget to analyze past year's expenditures to accurately project both succeeding year's operational and 5-year Special Repairs plans. • Monitors expenditures to ensure appropriate spending of Department of Finance approved budgets. Analyzes costs and oversees subordinate supervisor's analysis of costs to seek ways to control and reduce square footage costs as compared to BOMA expense comparisons for government facilities. • Directs the requisition, receipt and distribution of supplies, tools, and equipment to accomplish buildings and grounds work in accordance with DGS procurement laws and guidelines. Reviews all financial reports, including expenses and personal services providing variance explanations to demonstrate diligence in controlling allocated budget funds. • Utilizes ABMS reporting and time recording systems, Maximo, MS Office and other related software programs to provide written summaries of budget reviews to BPM Regional Manager.
15%	**Administrative and Supervisory Responsibilities** **Employee Leave Accounting** In order to maintain an accurate reporting to the State Controller's Office (SCO) for issuance of correct payroll warrants of subordinate staff's time or accurate reporting to the Office of Fiscal Services (OFS) for the billing of services for clients through the use of the Project Accounting & Leave (PAL) system in accordance with DGS policies and guidelines, MOU provision and State Personnel Board or Department of Personnel Administration laws and rules, and effectively manages and directs subordinate staff in accordance with established Equal Employment Opportunity and personnel policies, rules and regulations: • Grants or denies subordinate staff request for time off or requests to work overtime. • Ensures subordinate staff has sufficient leave credits available for the requested leave. • Oversees supervisors who enter subordinate's time in PAL system, i.e., time charged to projects, leave usage, approved leave without pay (dock or NDI), Absence without Leave (AWOL), etc. • Approves PAL entries for subordinate staff on dock or AWOL on or before the designated SCO's semi-monthly or monthly payroll cut-off date in order to ensure issuance of a SCO warrant for pay day.

% of time performing duties	Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
	• Approves or disapproves PAL entries for subordinate staff within three (3) working days after the completion of the pay period. This is to ensure the correct issuance of a SCO warrant that is returned to SCO for late dock, issuance of correct overtime pay due to an employee and proper billing to clients for services rendered.
	Employee Performance In order to effectively manage, coach, and direct subordinate staff in accordance with DGS constructive intervention process, Office of Legal Services direction, an established personnel, equal employment opportunity, and MOU provisions, policies, rules and regulations: • Identifies performance expectations utilizing probationary reports and/or Individual Development plans and convey expectations to the employee via written and verbal communication/direction. • Monitors performance through various production documents, supervisor's daily reports, personnel observations, and by following-up with employee to ensure that performance expectations are being met. • Provide feedback to employees on performance noting exceptional performance as well as areas of improvement through regular discussions. • Sustain employee performance using the departmental constructive intervention and progressive discipline principles and processes. • Prepares daily, weekly and monthly management unit reports to Regional Manager using established BPM forms and report formats.
15%	**Staffing Level Responsibilities** In order to avoid the loss of coded budgeted positions and to maintain adequate staffing levels for maintenance, engineering, grounds or custodial operations in accordance with Section 14699 through 14973 of the Government Code, the Excellence in Public Building Initiative, and Building Office Management Association (BOMA) industry standards: • Follows the BPM's Request for Personnel Action (RPA) process for recruitment of vacant or new positions. • Reviews the duty statement and organizational chart provided by the Business Operations Policy & Planning (BOPP) Personnel Liaison (PL) for accuracy on the specific position being recruited. • Posts the Employment Opportunity Bulletin (aka JOB) and the Local Post & Bid (P&B) form, if applicable, at the work sites of your employees. • Conducts hiring interviews after verifying eligibility with the Office of Human Resources' (OHR) staff. • Advises all appropriate personnel of candidate selection/proposed hire securing departmental approvals, ensuring pre-hiring requirements (documents) are completed and cleared by OHR, and proposed start date has been communicated to OHR through telephone or email communication.
10%	**Project Management** The Office Building Manager II coordinates on behalf of building/tenant alterations and capital improvements/special repairs: • Reviews plans, specifications, change orders and monitors their progress to ensure quality control of building standards to preserve the integrity of asset design thereby protecting the State's and occupant's investment. • Maintains cooperative team relations with other RESD units responsible for elements of project completion, contractors, building staff, tenants during project construction. • Proactively participates to resolve project problems in order to maintain timeliness of schedule and

% of time performing duties	Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
	quality control to promote good tenant experience. • Responds promptly to emergencies via telephone and personal visits to the property or area to assess overall damage caused by emergency event(s) and to ensure damage mitigation by organized, prompt and timely repair. • Coordinates and directs disaster recovery plans to return building and occupant operations to avoid building shutdowns.
5%	**Health and Safety** The Office Building Manager II administers health and safety programs to comply with laws and regulations, including, but not limited to: • Air toxins, emissions, CFC's (AB 2588); Asbestos (AB 3713); Pesticides, hazardous wastes (PCB's); Safety training (AB 2189); Injury and illness prevention (IIPP); Worker's Compensation (Title 8 and SB 198.) • Collaborates with the Department of Industrial Relations, Occupational Health and Safety Administration Division (OSHA) to do thorough routine inspections of all state and privately owned buildings for safety requirements. • Directs staff on asbestos regulation requirements. • Prepares and implements plans for Emergency Response, Disaster Recovery and Business Resumption, Hazardous Materials and Waste Manifest to enact prompt mitigation responses upon immediate notice. • Interprets and notifies staff and/or occupants of newly established law requirements. • Modifies written maintenance/operational processes, record keeping and reporting to ensure proper training for all staff.
	MARGINAL FUNCTIONS Ensures that the technical building operations manuals or technical equipment functions are understood by the appropriate staff by providing training or assigning the reading of same in order to provide compliance with the general functions of the branch as mandated by Government Code Sections 14600 through 19473 and the Excellence in Public Buildings Initiative. Oversees and directs the performance of corrective work including, but not limited to, resetting computer controls for buildings' systems such as life safety, mechanical, lighting, security in order to return a building to normal function in accordance with owner's manuals by following the manufacturer's operating guidelines and specifications. **KNOWLEDGE AND ABILITIES:** Knowledge of: Methods of caring for large public buildings and grounds; repair and operation of various types of building equipment; kind, quality, and amount of material and supplies used in building and ground maintenance and methods used in requisitioning, receiving, checking, storing, and issuing them; modern methods of heating, lighting, cleaning and ventilating large buildings; requirements, methods, and practices of the common trades and crafts; principles of personnel management and effective supervision; department's Affirmative Action Program objectives; a manager's role in the Affirmative Action Program and the processes available to meet affirmative action objectives. Ability to: Read and write English at a level required for successful job performance; maintain discipline over a large maintenance, repair and custodial staff; read and interpret plans, drawings, and specifications; estimate the cost of materials and labor involved in making alterations; maintain records and prepare

% of time performing duties	Indicate the duties and responsibilities assigned to the position and the percentage of time spent on each. Group related tasks under the same percentage with the highest percentage first. *(Use additional sheet if necessary)*
	concise reports; maintain cooperative relations with building occupants; analyze situations accurately and take effective action; effectively contribute to the department's affirmative action objectives.
	DESIRABLE QUALIFICATIONS: **SPECIAL PERSONAL CHARACTERISTICS** • Willingness to work in any regional location. • Possession of a Valid California Driver's License, Class C. **ADDITIONAL QUALIFICATIONS** • Work independently, organize, and set priorities. • Broad understanding of real estate principles and business management. **INTERPERSONAL SKILLS** • Work well with a team; motivate staff; deliver high quality customer service; maintain good working relationships; communicate information, both verbally and in writing, in a clear and concise manner. • Display efficiency, effectiveness, conscientiousness and professionalism. **WORK ENVIRONMENT, PHYSICAL OR MENTAL ABILITIES:** **WORK ENVIRONMENT** • Work in office building environment ranging from single story to eighteen stories. • Business office environment. • Wear appropriate business attire for the work environment. • Make prompt decisions and meet ever-changing deadlines. • Multi-task. • Occasional exposure to mechanical equipment open and confined spaces. • Occasional exposure to noisy work areas, equipment or machinery. • May require valid California Driver's License, Class C in order to drive self from building sites to building sites. • Willingness to work in any regional location and to work hours necessary to mitigate a building emergency, meet deadlines or complete tasks. • **May require a Department of Justice background and/or fingerprinting check to work in buildings/floors occupied by the DOJ.**
	PHYSICAL ABILITIES • **Typical work activities involve frequent and prolonged periods of standing, walking extended distances, bending, stooping, kneeling or squatting while performing duties.** • **May climb stairs and/or ladders.** • **Reach or stretch by extending hand(s) or arm(s) in any direction.** • **Move about and work in confined spaces.** • **Drive a State Vehicle to field locations.** **MENTAL ABILITIES** • **Make prompt decisions and meet ever-changing deadlines.** • **Broad understanding of real estate principles and business management.**

Integrating Building Commissioning into State Building Construction

Appendix B: UC Davis Job Descriptions

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016

Arnold Schwarzenegger, *Governor*

Subtask 2 Deliverable

16.0 UC Davis Commissioning Analyst Position

UNIVERSITY OF CALIFORNIA, DAVIS

POSITION DESCRIPTION

Request for:

_X_Recruitment*

___Reclassification Review*

___Update Review

* PLEASE ATTACH A COPY OF A CURRENT ORGANIZATIONAL CHART (INCLUDING NAMES AND PAYROLL TITLES)

CLASSIFICATION UNIT USE ONLY

Approved Payroll Title
Code

_____

_____

CBUC_____ Effective Date
_____

Classifier _____
Date_____

1. Name (Last, First, Middle Initial) and Employee Identification Number (UCDMC use PCN#)

2. Current Payroll Title, Working Title, Department, and Phone Number
ANALYST IV, Commissioning Analyst

3. Supervisor, Supervisor's Payroll Title, and Phone Number

4. Briefly describe the role of this position within the department
Architects & Engineers manages the programming, design, and construction of new and remodeled major capital projects, with an active project load of nearly $800,000,000.

Provide commissioning support for all capital improvement projects. Update the general commissioning specification and guidelines, develop cost effective practices to improve the commissioning effort, perform economic analyses, identify and evaluate promising new technology, and assist project managers in managing the commissioning activities during construction. Other duties include performing engineering studies, design document review, and assisting the construction administration on large projects.

5. Special Conditions of Employment (refer to guidelines for completing position description forms before completing this section)
Non smoking work environment. Valid CA driver's license required. Work occasional evenings/nights. Work occasional weekends and holidays. Position requires lifting up to 50 lbs. Ability to climb ladders and several flights of stairs.

6. List positions supervised by this position (Payroll Title, #FTE):

7. Signatures

I have read this position description and understand its contents.

_____ _____
Employee **Date**

Immediate Supervisor	**Date**
Department Head	**Date**

8. Describe each essential function of this position in a separate paragraph. List the functions in descending order of importance. Please refer to the 'Guidelines for Completing Position Description Form' before completing this section. Next, indicate the frequency with which each function is performed, i.e., D=Daily, W=Weekly, etc. Finally, using percentages of not less than 5%, estimate the distribution of the total working time on an annual basis. Total percentage of time must add up to 100%, regardless of the % of time of appointment.**

A. DAILY 90% Commissioning

Provide leadership in developing and updating general building and infrastructure project commissioning outline and specification during project planning phases for all capital improvement projects. Review project design intent and with project teams, develop project specific commissioning requirements including commissioning specifications and documentation plans. Forecast and develop design and construction commissioning budgets and schedules. Provide leadership in developing, implementing, and supervising the commissioning activities during construction phase. Assist contractors in the development and utilization of the construction commissioning documentation plan and act as the University commissioning authority during construction. Verify installation, functional performance, training, and operation and maintenance documentation to ensure conformance with design intent. Assist project teams in implementing LEED, Labs 21, and Campus Green Building Design and Clean Energy initiatives for capital improvement projects in relations to commissioning requirements. Lead the data collection effort including performing energy surveys and simulation tests, analyzing and reviewing project performance, and proposing energy efficiency and performance improvement options. Perform building energy audits and conduct economic risk/benefit cost and life cycle cost analyses of energy systems. Review project documents at various phases of design to ensure the documents are coordinated; and meet applicable codes and standards, sound engineering practices, campus design guidelines, and the project program. Perform constructability reviews of project documents to minimize changes and conflicts during the construction phase. Participate in design round table meetings with project teams to ensure project needs are met and reflected in the design documents.

B. DAILY 0% Commissioning

Review submittals during construction and work closely with project consultants to verify that submitted materials meet contract requirements. Review and evaluate cost proposals for changes during the construction phase to verify the scope of change is accurate. When appropriate, propose alternative methods to improve the quality of the scope and/or reduce the project impact. Monitor construction progress, keep daily records of activities, review requests from contractors for progress payments, and attend periodic construction meetings. Review contractor progress on the drawings of record. Verify and inspect contractor's work to ensure work is completed in accordance with construction documents (verification can be by use of outside testing laboratory or by direct inspection). Participate in project visits with design teams to verify work, referring to supporting documents and codes as required. Work with other campus units and the Contractor to schedule activities to minimize impact to campus operations.

C. DAILY 10% Other Tasks

Assist Engineering Manager with various tasks associated with the campus capital building program. Assist in the preparation of graphics and technical reports. Perform other duties as assigned.

9. Describe the skills, knowledge, and abilities which are essential for successful performance of this position. List them in descending order of importance and describe the required level of each in terms of the functions performed. Next, indicate the function(s) for which each skill, knowledge and ability is required

Function Reference	Skills, Knowledge & Ability
All	Demonstrated working experience with commissioning building and central plant systems.
All	Demonstrated knowledge of energy conservation in mechanical and electrical systems.
All	Demonstrated working experience with energy management systems.
All	Knowledge of California Administrative Codes, Title 24 (CBC, CEC, CMC, CPC, CFC), and NFPA. Ability to apply energy analysis to new construction, alterations and modifications.
All	Experience with Leadership in Energy and Environmental Design (LEED), Labs for the 21st Century (Labs 21), Green Building Design and Clean Energy Standards (preferred).
All	LEED and Labs 21 certification (preferred).
All	Ability to initiate and maintain cooperative relationships with co-workers, managers, supervisors, clients, contractors, consultants and members of the public. Skill, ability, or experience to contribute as a team player in a respectful and professional environment.
All	Excellent oral, written, and interpersonal communication skills to interact with a diverse group of individuals with varying technical skills and understanding.
A	Experience working with Energy Management Systems (EMS) preferred.
A	Ability to recognize proper construction techniques and evaluate quality or workmanship.
All	Demonstrated working experience reviewing, interpreting and understanding mechanical/civil/electrical plans, specifications, shop drawings, placement drawings, test reports, codes and regulations pertaining to construction, construction safety and hazardous materials.
All	Knowledge and advanced skills to operate custom computerized systems for report development, creation of budgets, statistical data and correspondence. Working knowledge of Microsoft Word, Excel, Outlook and Project (XP/2003) in a Windows environment; and document management database programs (Lotus Notes). Working knowledge of energy models and related computer software is a plus.
All	Strong skill to organize work effectively to achieve timely progress on multiple simultaneous projects. Ability and skills to work independently and follow through on assignments with minimal direction.

2.0 UC Davis Senior Engineer Position

UNIVERSITY OF CALIFORNIA, DAVIS

POSITION DESCRIPTION

Request for:

_X_Recruitment*

___Reclassification Review*

___Update Review

* PLEASE ATTACH A COPY OF A CURRENT ORGANIZATIONAL CHART (INCLUDING NAMES AND PAYROLL TITLES)

CLASSIFICATION UNIT USE ONLY

Approved Payroll Title
Code

_____
_____

CBUC_____ Effective Date
_____

Classifier _____
Date_____

1. Name (Last, First, Middle Initial) and Employee Identification Number (UCDMC use PCN#)

2. Current Payroll Title, Working Title, Department, and Phone Number
SENIOR ENGINEER - SUPERVISOR, Engineering Manager

3. Supervisor, Supervisor's Payroll Title, and Phone Number

4. Briefly describe the role of this position within the department
Architects & Engineers manages the programming, design, and construction of new and remodeled major capital projects, with an active project load of over $800,000,000.

Provide leadership for the Engineering Group consisting of electrical, mechanical, and civil engineers. Manage various activities including analysis of site utilities; design review of mechanical, electrical, site utilities and central plant systems; and analysis of engineering systems and equipment for building projects. Responsible for leading technical inspections during construction, commissioning, infrastructure load forecasting and infrastructure planning.

5. Special Conditions of Employment (refer to guidelines for completing position description forms before completing this section)
Non smoking work environment. Valid CA driver's license required. Work occasional overtime including evenings and weekends as required to meet operational needs. Current license as a professional mechanical or civil engineer in the State of California. Ability to use a computer for extended periods of time.

6. List positions supervised by this position (Payroll Title, #FTE):
Analyst V 1.00 FTE
Associate Engineer 4.00 FTE

7. Signatures

I have read this position description and understand its contents.

_____ _____
Employee **Date**

Immediate Supervisor	**Date**
Department Head	**Date**

8. Describe each essential function of this position in a separate paragraph. List the functions in descending order of importance. Please refer to the 'Guidelines for Completing Position Description Form' before completing this section. Next, indicate the frequency with which each function is performed, i.e., D=Daily, W=Weekly, etc. Finally, using percentages of not less than 5%, estimate the distribution of the total working time on an annual basis. Total percentage of time must add up to 100%, regardless of the % of time of appointment.**

A. DAILY 20% Supervision and Leadership

Provide direct supervision and training of employees covered by staff policy and/or collective bargaining agreement. Interview, select, and mentor staff. Monitor, evaluate, and manage the performance of staff. Determine, distribute, and supervise the work performed. Forecast, assess, and plan for personnel and resources needed to meet departmental goals. Reorganize or vary responsibilities of staff to improve work distribution and productivity to meet operational needs. Provide opportunities for staff development. Strive to meet affirmative action goals.

B. DAILY 30% Engineering Studies and Infrastructure Planning

Directly responsible for leading engineering studies and analysis work for a variety of building and campus systems including HVAC, plumbing, process piping, controls, energy, fire protection (sprinkler and alarm), electrical, telecommunications and site utilities. Develop cost estimates and analysis with consideration to capital costs and operating & maintenance costs (life cycle costing). With staff, develop and publish quarterly updates on campus utilities. Oversee the performance of site utility feasibility studies for chilled water, steam, natural gas, electrical systems, telecommunications, water, sanitary sewer, and storm drainage during project development phase. Develop short- and long-term solutions to campus utility deficiencies.

C. DAILY 35% Design and Construction Support

With project managers, take a leadership role in developing mechanical and electrical requirements for capital projects. With staff, review basis of design for capital projects to ensure compliance with campus standards, program requirements, building codes and sound engineering practice. Systems under the purview of the Engineering Group include HVAC, plumbing, process piping, controls, energy, fire protection (sprinkler and alarm), electrical, telecommunications and site utilities. Take an active role in the value engineering process. Work with project managers to solve technical and cost problems during the design phase. With the Energy Engineer and the project team, provide leadership in solving energy related technical issues during the design phase. Serve as a resource on energy related items associated with LEED, Lab 21 and Campus Green Building Design and Clean Energy initiatives for capital improvement projects. Review submittals and shop drawings, working closely with the consultant team to verify that submitted material meets contract and campus requirements. Review and provide input in the development of construction cost estimates. Review change orders when requested and Requests for Information. Serve as a liaison with the Operations and Maintenance department for project design review and coordination.

D. DAILY 15% Commissioning

Oversee the development and updating of building and infrastructure project commissioning outlines and specifications during the planning phase for all capital improvement projects. Review project design intent and with project teams, develop project specific commissioning requirements including commissioning specifications and documentation plans. Forecast and develop design and construction commissioning budgets and schedules. Manage the activities of the construction administrators within the Engineering Group. Tour job sites periodically. Ensure Construction Administrators follow all applicable requirements, codes, policies and guidelines. Directly responsible for commissioning

engineering systems for major capital projects. Perform other duties as assigned.

9. Describe the skills, knowledge, and abilities which are essential for successful performance of this position. List them in descending order of importance and describe the required level of each in terms of the functions performed. Next, indicate the function(s) for which each skill, knowledge and ability is required

Function Reference	Skills, Knowledge & Ability
All	Thorough knowledge of and experience with mechanical/electrical engineering practices and procedures. Skills to appropriately apply them to meet the University's building program requirements and objectives.
All	Thorough knowledge of California and industry building codes and regulations.
All	Extensive experience with infrastructure design, installation, and cost estimating.
All	Demonstrated experience reviewing design documents for large capital improvement projects.
All	Demonstrated experience performing engineering studies and analysis.
All	Experience providing leadership and planning operations for construction administration staff.
All	Knowledge of Leadership in Energy and Environmental Design (LEED), Labs for the 21st Century (Labs 21), Green Building Design and Clean Energy Standards (preferred).
All	Knowledge of project constructability and skills to anticipate problems in implementation of design. Ability to recommend alternative approaches to eliminate such problems.
All	Ability to gain the confidence, trust and support of a diverse group of people in order to reach established goals.
All	Demonstrated experience supervising personnel including recruitment, training, work assignment, setting expectations, evaluating performance, and initiating reward or corrective action as required. Ability to motivate employees and maintain good morale. Skills to articulate procedures and processes to staff.
All	Excellent oral and interpersonal communication skills to work as a team member to communicate in a pleasant, professional and effective manner; and to handle difficult, sensitive, and/or confidential issues.
All	Financial skills to develop and manage project budgets.
All	Knowledge of construction sequences and practices to prepare, review, and evaluate project schedules.
All	Interpersonal skills necessary to represent the University in negotiations with construction personnel and come to a fair agreement for both parties.
All	Strong skill to organize work effectively to achieve a timely progress on multiple simultaneous projects. Ability to work independently and follow through on assignments with minimal direction.
All	Ability to initiate and maintain cooperative relationships with people from diverse backgrounds. Skill, ability, or experience to contribute as a team player in a respectful and professional environment.
All	Knowledge and advance skills to operate custom computerized systems to prepare correspondence, reports, budgets, and schedules. Working knowledge of word processing, spreadsheet, calendaring, project management, and document management database programs (Microsoft Word, Excel, Outlook, Project, and Lotus Notes preferred) in a Windows environment (XP/2003).

Appendix B:
Task 3 Report - Estimate of Statewide Benefits of Integrating Cx into State Building Construction Projects

Integrating Building Commissioning into State Building Construction

Appendix B: Task 3 Report - Estimate of Statewide Benefits of Integrating Cx into State Building Construction

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
August 2009

Arnold Schwarzenegger, *Governor*

CALIFORNIA ENERGY COMMISSION

Prepared By:
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Boulder, Colorado
Commission Contract No. 500-04-016

Program Director
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DISCLAIMER

This report was prepared as the result of work sponsored by the California Energy Commission. It does not necessarily represent the views of the Energy Commission, its employees or the State of California. The Energy Commission, the State of California, its employees, contractors and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the California Energy Commission nor has the California Energy Commission passed upon the accuracy or adequacy of the information in this report.

Integrating Building Commissioning into State Building Construction

Estimate of Statewide Benefits of Integrating Commissioning into State Building Construction Projects – Final

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
December 2008

Arnold Schwarzenegger, *Governor*

Subtask 3.0 Deliverable

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Contract Manager

Norm Bourassa
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B.B. Blevins
Executive Director

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Acknowledgements

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by binging environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

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For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research or contact the Energy Commission at 916-654-5164.

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Abstract

The goal of the Integrating Building Commissioning into State Building Construction program is to improve the realization and persistence of proper operation and resource efficiency in new State buildings, resulting in lower energy use, lower operation and maintenance costs to the State, longer building life, as well as greater worker productivity and user comfort.

This Task 3 Report analyzes the cost and benefits of building commissioning, ultimately to substantiate a Capital Outlay Budget Change Proposal (COBCP) to fund additional staff within the California Department of General Services (DGS) to manage and/or perform commissioning. It does so through a literature review, interviews with DGS staff, commissioning professionals and team members, and a pilot study using a current DGS project in Marysville.

1.0 Executive Summary

The California Department of General Services (DGS) intends to integrate commissioning (Cx) into its building delivery process. The California Energy Commission (CEC), through its Public Interest Energy Research (PIER) Program, is providing assistance in developing a commissioning implementation plan for DGS. This report, reflecting work on Task 3 of the Integrating Building Commissioning into State Building Construction Program, describes the costs and benefits of incorporating commissioning into state building projects.

This report is based on literature reviews, interviews with DGS staff and Cx professionals, and a Cx pilot study of a current DGS project in Marysville. Benefits of Cx are quantified through avoided costs (realized especially during design review and construction inspections) and annual energy and maintenance/repair savings. "Qualified benefits" are extensive: improved building operation, thermal comfort and air quality for occupants, effective training for building operators, reduced change orders and improved communications during construction, and many "lessons learned" carried forward for future design, construction and maintenance processes.

Previous studies and a case study database by the California Commissioning Collaborative have shown that Cx on new buildings cost $0.55 to $1.10 per square foot, or 0.4 to 1.5% of the cost of construction. At Marysville, Cx cost $0.59/sf, but it achieved an avoided one-time cost benefit of $.61/sf and annual savings of $46K. Cx costs vary depending on the complexity of the project, when Cx services commence, which systems are being commissioned, and additional monitoring that may be performed post-occupancy. Third-party Cx cost data was not provided to evaluate past and current spending by DGS on their new construction projects. This would be a valuable exercise to ascertain if the third-party cost of Cx per square foot is congruent with the CCC database and cost-benefit studies discussed in this report.

Retro-commissioning (RCx) is performed on existing buildings and is found to cost $0.27 to $0.49/sf, resulting in an annual energy savings of $0.27/sf to $0.40/sf. It is easier to quantify these RCx savings because baseline energy costs are available for comparison; annual energy savings have been significant. New Cx relies on "what if" estimates, assumptions, and energy models to quantify annual energy savings and other benefits such as cost reduction or avoidance during design review and/or construction, reduced call-backs during start-up or warranty phases, and improved operations and reduced maintenance.

A majority of studies and interviews conclude that Cx is a valuable process that should be implemented on most construction projects as early into the design phase as possible. Understanding and support of Cx by the owner is critical and facilitates better cooperation between the designers, general contractor, sub-contractors and Cx professionals. Several major institutions have adopted Cx wholly and have acquired staff to oversee or perform Cx on all of their construction projects. Payback periods (typically one year or less) are attractive and the occupant/operator benefits and institutional memory are invaluable.

2.0 Introduction

California State legislation requires that all buildings greater than 10,000 sf be certified to the Leadership in Environmental and Energy Design (LEED) Silver level, which includes basic building Cx as a prerequisite. However, DGS wants to evaluate how to apply Cx to a majority of its projects, in addition to optimizing the process on LEED projects. Other related work described in separate reports includes assessment of options for delivering commissioning (Task 2), and an implementation plan for commissioning (Task 4).

Information about the benefits and costs of commissioning is needed by the State to justify allocating funds for commissioning staff and activities. The intent of this report is to provide information needed as part of the Capital Outlay Budget Change Proposal (COBCP) process to justify establishing commissioning positions within DGS and to provide project funding for commissioning.

The most significant study of Cx to date is the 2004 study by Evan Mills and Lawrence Berkeley National Labs titled, *The Cost Effectiveness of Commercial-Building Commissioning*[1]. It is often referenced in subsequent papers on Cx costs and benefits which are also reviewed. These other studies do not research nearly the quantity of sites covered by the Mills study, but they all provide ample qualification of the Cx process and the value it brings to new and retro-commissioning (RCx) projects.

The California Commissioning Collaborative has compiled approximately 59 case studies to date and provides a link to each on their website, www.cacx.org. Twenty-four of these were new building Cx and the remaining 35 were RCx. About two-thirds of the studies provide the cost of Cx and the Annual Energy Savings as a result of Cx. Just as importantly, though, are the narratives and/or lists of lessons learned through the process.

Task 5 is to perform Cx at the CALTRANS District 3 New Offices project in Marysville, CA. This started in early 2003 with conceptual design. Construction started in March, 2007, and occupancy started in early December, 2008. While the Task 5 report will summarize DGS integration into Cx as a case study, a cost-benefit study of Marysville is provided herein.

DGS experience with Cx on other past projects is also used as a source of cost/benefit information. This information is gathered primarily through interviews with DGS staff and other project team members, primarily from the Project Management Branch (PMB), the Construction Services Section (CSS) of the Professional Services Branch (PSB) and the Building and Property Management (BPM) Branch. Most value the Cx process, especially building operators from BPM that have such practical sensibilities towards the systems being commissioned. For this reason, it seems most appropriate for Cx services within DGS to be

[1] Mills, Evan, et al, The Cost-Effectiveness of Commercial-Buildings Commissioning, A Meta-Analysis of Energy and Non-Energy Impact in Existing Buildings and New Construction in the United States, December 15, 2004, LBNL – 56637 (Rev.)

housed in this branch, but in a team-based framework that includes certain other branches and sections within DGS. (The Task 4 and 6 reports elaborate on this theme.)

3.0 Literature Review

3.1. Mills 2004, The Cost Effectiveness of Commercial-Building Commissioning

The most current and comprehensive study on the cost and benefits of commercial building commissioning (Cx) is the 2004 study by Evan Mills with Lawrence Berkley National Labs (LBNL), *The Cost Effectiveness of Commercial-Building Commissioning*[2]. It used a meta-analysis to analyze commissioning and retro-commissioning (RCx) of 224 buildings across 21 states. For existing buildings, the study found that a median energy cost savings of $0.27/sf, or 15% energy savings, can be achieved by spending the same $0.27/sf on retro-commissioning. For new buildings, the median commissioning cost was $1.00/sf, or 0.6% of total construction cost (excluding non-energy impacts). Tables 7 and 8 from this study provide a results summary with quartile analysis for both new and RCx; these are provided in Attachment I.

A majority of the study samples were retro-commissioning (106 projects or 150 buildings) as compared to new construction Cx (69 projects or 74 buildings). Median annual energy savings for RCx projects was $0.27/sf as compared to $0.05/sf for new construction Cx.

Non-energy impacts (NEIs) were evaluated on 44 new construction projects, and include:

- Longer equipment lifetime.
- Improved thermal comfort and indoor air quality.
- Reduced change orders and warranty claims ("first-cost" reductions).
- Improved productivity and safety.
- In 22 cases, economic value of these impacts could be quantified: a median savings of $51,000 per project or $1.24/sf was calculated. This exceeds the median $1.00/sf cost of Cx (based on a sampling of 69 projects).

A few key observations of the study include:

- "New construction is more strongly driven by non-energy objectives such as overall building performance, thermal comfort, and indoor air quality, whereas existing building commissioning is more strongly driven by energy savings objectives."
- "The need for commissioning in new construction, however, is indicated by the observation that the number of deficiencies identified in new-construction exceeds that for existing buildings by a factor of three."
- "The most cost-effective results occurred among energy-intensive facilities such as hospitals and laboratories. Less cost-effective results are most frequent in smaller

[2] Mills, Evan, et al, The Cost-Effectiveness of Commercial-Buildings Commissioning, A Meta-Analysis of Energy and Non-Energy Impact in Existing Buildings and New Construction in the United States, December 15, 2004, LBNL – 56637 (Rev.)

buildings. Energy savings tend to rise with increasing comprehensiveness of commissioning."

Through 2008, Evan Mills was receiving additional data from 20 Cx projects at University of California and California State University (UC/CSU) sites, 2 high-tech projects within LBNL, and 60 projects from Texas A&M University. He will be revising his 2004 report with this new data in early 2009.

3.2. D'Antonio 2007, Costs and Benefits of Commissioning LEED-NC Buildings

In 2007, Peter D'Antonio presented his study *Costs and Benefits of Commissioning LEED-NC Buildings*[3] at the 2007 National Conference on Building Commissioning. While the sample size was small (11 LEED buildings), it provides case studies and a budget range for both soft and hard costs of LEED certification and commissioning. The total LEED cost premium ranged from $0.70/sf to $20/sf, or 1% to 6% of construction costs. Of this, soft costs (LEED registration, certification, and documentation, energy modeling, and commissioning) averaged $1/sf or 0.8% of construction costs. And out of this, $0.55/sf was for commissioning. Hard costs include added expenses of specific LEED related decisions. All projects except one incorporated enhanced commissioning (LEED Energy & Atmosphere Credit 3) where the commissioning process begins in the design phase and requires additional monitoring beyond system start-up. The majority of the teams found the commissioning process to be valuable, with only one having negative experiences and the opinion that the process is too documentation intensive.

3.3. Ellis 2006, Quantifying Costs and Benefits, the Sequel: A 6 Year Check-up on Commissioning at the Pentagon

In 1998, the Pentagon decided to incorporate commissioning into its $1.1 billion Renovation program. A cost-benefit analysis of commissioning was performed after the first 2 years, and then revisited and summarized in the 2006 study *Quantifying Costs and Benefits, the Sequel: A 6 Year Check-up on Commissioning at the Pentagon*[4]. The paper is presented in two sections: "Financial Costs and Benefits" and "Commissioning Process Lessons Learned". The study quantified a "total life cycle cost savings" due to commissioning and assigned each to 3 benefit categories: project, facility, and tenant. These are further defined in Table 1, which follows.

[3] D'Antonio, Peter, Costs and Benefits of Commissioning LEED-NC Buildings, National Conference of Building Commissioning, May, 2007.

[4] Ellis, Rebecca T., et al, Quantifying Costs and Benefits, the Sequel: A 6 Year Check-up on Commissioning at the Pentagon, National Conference of Building Commissioning, April, 2006.

Table 1: Total Life Cycle Cost Savings Benefits Categories, Pentagon Study.

Project	Facility	Tenant
• Reduced change orders • Reduced requests for information • Expedited problem resolution • On-time project completion • Reduced warranty calls • Improved perception of project success	• Reduced energy consumption • Decreased O&M staff time to find/correct problems after turnover • Decreased O&M budget demand to correct problems after turnover • Improved preventative maintenance • Improved predictive maintenance • Improved trouble call responsiveness	• Staff productivity • Process productivity

The cost of commissioning in this study was defined as only the commissioning specialist's fee. Based on the initial 18 months of data collection, 68 items were identified in the database. Of these, 23 were quantified with an average commissioning cost of $2,500 per benefit. This represented 1.0% of construction costs. The cumulative benefit values, including project, facility, and tenant categories, averaged $125,000/benefit. This figure is based on all identified (not just quantified) benefits through 2005. Between 1998 and 2000, the sum of benefit values reached almost $5 million. At the end of that same period, the actual cost of commissioning was at $2.5 million, or half of the benefit value. Hence, the formal collection and analysis of benefits was discontinued at that time.

The 2006 paper expands these financial results from 2000 with "lessons learned". These include:

- Test Sampling Strategies: Only perform 100% testing on mission critical and life safety systems. Set a sampling rate and failure limit for other systems. If the failure limit is exceeded, the contractor must test the entire system.
- Best Value Testing Strategies: Contractors should work on their own to confirm that their systems will pass the entire functional performance testing in a single session. Failures increase testing which drive up Cx costs. Partial functional performance tests (FPTs) should be avoided.
- System Un-Readiness for Testing: Cx agents are often pressured to witness FPTs that aren't ready for testing, despite efforts requiring pre-functional checklist completion. They should not bow to the pressure and the owner needs to back this position.

- Flexibility in Commissioning Approach: Bring Cx goals and objectives to a level of rigor and cost appropriate to each project. The Pentagon developed a Cx "Lite" Plan for application to small and less critical projects where full-blown Cx would not be cost effective.
- Failure Definition and Management: The Pentagon project stated that "Failure of a single step of the test procedure constitutes and failure of the entire FPT." This applies even to failures that are corrected in the field during testing. They established a 5-minute rule for making corrections, but they tried to prevent this from becoming a habit due to the loss of efficiency and very real impact on the bottom line for each of the commissioning team members.
- Failure Management: At building turnover, it is not uncommon for as many as 8% of FPTs to remain incomplete. Metrics should be developed and adhered to when evaluating contractor pay applications.
- Training Building Users and Operators: "If there is one predominant lesson learned, it is that the benefits to the operations and maintenance (O&M) staff will only be realized if the O&M staff is interested in representing their own interests in the Cx process."

3.4. Doty 2006, Simplifying the Commissioning Process

Steve Doty of the Colorado Springs Utilities wrote *Simplifying the Commissioning Process*[5] in June, 2006. The paper defines Cx, provides "Tips for Applying Cx", and quantifies Cx benefits in a very practical way. He describes the role of all team players affected by Cx and how they should envision their role in the Cx process. The goal is to understand the needs and expectations of each person from the designer to the operator. Examples of what to look for in the design, construction, and turnover phases are ample. His tips for applying Cx include:

1. *What To Look For in a Cx Provider*. In addition to experience requirements, he stresses the need for good communication skills and the team approach for a successful Cx process.
2. *Owner Involvement – The Key Ingredient*. The Owner must facilitate Cx among the design and construction teams from the beginning.
3. *When to Use Cx*? Even though all projects can be improved on, not all should be commissioned. Consider Cx on any mission critical system, at a minimum. And if quality ranks first or second in a list of considerations with price and schedule, the project is likely going to justify the cost of Cx.
4. *What Does Cx Cost?* Cx costs (from the 2002 PECI study discussed in this Task 3 report), as a percentage of construction or replacement cost, are presented in a table comparing project cost with the type of construction (new-detailed, new-basic, and RCx).
5. *What Cx WILL and WILL NOT Do For The Owner - Setting Realistic Expectations*. The "Will-Do" list expands upon most of the benefits discussed in this Task 3 report. It points out

[5] Doty, S., *Simplifying the Commissioning Process*, Colorado Springs Utilities, June, 2006.

that Cx does not replace owner involvement or contractors' quality control activities during construction.

6. Overcoming Resistance to Cx. He discusses the "social" aspects that cause resistance to Cx, such as how it is perceived to highlight problems and to cause adversarial relations between project team members.
7. Answering the 'Overlap of Duties' Argument. Cx is sometime perceived as paying "twice" to insure quality that should come from the contractors regardless of Cx. He points out the value of Cx overseeing the project from a different perspective (the Owners Project Requirements and Basis of Design) and additional sampling that otherwise would probably not occur.

In "Quantifying Commissioning Benefits," Doty recommends that savings be quantified as:

- Avoided First Cost.
- Avoided Future Repair or Replacement Cost of a Defect.
- Reduced Maintenance Cost.
- Reduced Energy Cost.

He stresses that quantifying all Cx benefits is not easy and that assigning a dollar value where the rationale is "a stretch" reduces credibility. However, they should be qualified as issues and tracked to demonstrate the value added by Cx reviews and inspections. His 10 sample Cx measures all define the measure or "rationale", then lists the assumptions made for calculations (when quantifiable) or qualifies how it "could" affect future costs, and finally presents the calculation in each of the four categories above. He also recommends using a 10-year project life to be very conservative, and illustrates Internal Rate of Return relative to Simple Payback Period as an alternative way to value Cx.

3.5. SBW Consulting 2003, Cost-Benefit Analysis for the Public Sector Commissioning Project

In June, 2003, SBW Consulting, Inc. submitted its report *Cost-Benefit Analysis for the Public Sector Commissioning Project*[6] to the Northwest Energy Efficiency Alliance (NEEA). Some of the data was incorporated in the 2004 LBNL study. NEEA started the Commissioning in Public Buildings project in 1998, looking at 33 projects (both new and existing) in the Pacific Northwest. SBW quantified the energy and non-energy impacts for 21 of the 33 commissioning projects and then calculated payback ratios for each. The ratios were categorized as direct payback (i.e. reduced energy use and the commissioning agent cost) and total payback (i.e. including non-energy impacts and non-billable time spent). For new buildings, the payback for commissioning was 6.1 years, as compared to 3.2 years for retro-commissioning. This occurred

[6] SBW Consulting and Skumatz Economic Research Associates. 2003. *Cost Benefit Analysis for the Commissioning in Public Buildings Project*. Northwest Energy Efficiency Alliance.

because the energy savings from RCx projects were 49% higher and initial costs were 22% lower. The cost of commissioning averaged $0.85/sf for new buildings and $0.31/sf for existing buildings.

Of all of the reports reviewed, this was very comprehensive and provided a thorough description of how costs and benefits were quantified, including good examples of ongoing impacts vs. one-time impacts, energy vs. non-energy impacts, and direct vs. indirect impacts. A significant part of this study involved a review of Cx reports, issue logs, design review memoranda and interviewing Cx team members. It concludes that the most valuable indirect non-energy benefits were reduced operational deficiencies and improved occupant comfort. Other benefits were:

- Reduced time needed to optimize building systems during construction.
- Increased O&M staff knowledge.
- Improved indoor air quality.

3.6. Portland Energy Conservation, Inc. (PECI), *Establishing Commissioning Costs*, Revised 2002

PECI completed Cx costing studies in 2000 and updated results in 2002. The focus was primarily on HVAC system commissioning with a further discussion of cause for variability in Cx costs. Design phase Cx costs range from 0.1 to 0.3% of construction costs, with Cx professionals accounting for 75% and the designer the remaining 25%. Construction phase Cx of HVAC, controls, and electrical systems ranges from 0.5 to 1.5% of construction costs. This covers only the Cx agent's fees. PECI reported that the cost for the contractors for attending meetings, documentation, and testing will roughly equal 10 to 25% of the Cx agent's cost. PECI stresses that these rules of thumb should be used with great caution; understanding what is and is not included in each Cx project is critical.

3.7. California Commissioning Collaborative Case Studies

The California Commissioning Collaborative (CCC) "is a non-profit 501(c)3 organization committed to improving the performance of buildings and their systems. The CCC is made up of government, utility and building service organizations and professionals who have come together to create a viable market for building commissioning in California." Their website www.cacx.org provides a link to 60 Cx case studies. Each is a one- to four-page narrative giving project information, cost and energy savings data (when available), and Cx lessons learned. For Task 3, AEC compiled the data into a spreadsheet provided in Appendix A. By grouping the 25 and 35 new Cx and retro-Cx projects, respectively, the average and median Cx $/sf values for each were calculated. For the 25 new construction Cx projects, an average cost of $1.01/sf and median cost of $1.10/sf were calculated, compared to the average RCx cost of $0.69/sf and median RCx cost of $0.49/sf. Table 2 summarizes the median and average values tabulated from the case studies.

Table 2: Summary of $/sf Values from CCC Case Studies.

	New Commissioning	Retro-Commissioning
Cx cost $/sf – Median	$1.10 per sf	$0.49 per sf
Cx cost $/sf – Average	$1.01 per sf	$0.69 per sf
First Year Cost Benefit $/sf – Median	$0.19 per sf	$0.16 per sf
First Year Cost Benefit $/sf – Average	$0.18 per sf	$0.17 per sf
Annual Energy Savings $/sf – Median	$0.14 per sf	$0.24 per sf
Annual Energy Savings $/sf – Average	$0.13 per sf	$0.40 per sf

Qualitative data varied for each project, but some of the most common lessons learned included:

- Start Cx as early in the design process as possible. By reviewing contract documents in the early stages, many problems and changes during the construction process can be avoided.
- Cx improved occupant comfort and indoor air quality (common on most RCx projects).
- Fewer start-up and warranty issues, change orders, and better operations occur upon occupancy on new Cx projects.
- Operations and maintenance staff receive better training.

One mechanical contractor alluded, "At first it seemed to be just another added hoop to jump through, but as the problems started to come out with the testing, it became obvious that commissioning was an added benefit to the job. By finding out and solving problems before the warranty started, it saved us countless hours and dollars in chasing nuisance complaints from the occupants."

Several of the studies provided justification for bringing Cx services for future projects in-house, and a majority of the Cx on the University of California/California State University (UC/CSU) project were partly performed by in-house staff.

3.8. Literature Review Summary

Table 3 summarizes the numerical cost and payback data from the studies discussed. For new construction, the 3 studies with a significant sample size (Mills, SBW, and CCC) demonstrated a range of Cx cost per square foot of $0.85 to $1.10. As a percentage of construction, Cx cost 0.4% to 1.2% of the project construction cost.

Table 3: Summary of Cx Cost and Payback from Literature Review.

	Cx Cost and Payback		
	Cx Cost		Payback
Name/Date of Study	$/SF	% of construction cost	(years)
Mills, LBNL, 2004			
New	$1.00	0.6%	4.8
RCx	$0.27	n/a	0.7
Ellis, Pentagon, 2006			
New	n/a	1.0%	n/a
D'Antonio, LEED-Colorado, 2007			
New	$0.55	0.4%	n/a
SBW, NEEA Study, 2003			
New	$0.85	n/a	6.1
RCx	$0.31	n/a	3.2
PECI, 2002			
New	n/a	0.5-1.5%	n/a
CACx Database			
New (median $/sf)	$1.10	0.4-1.2%	n/a
RCx (median $/sf)	$0.49	n/a	n/a

Only two studies put a cost per square foot value on the benefits of new construction Cx. As there is no baseline for new Cx, these values are more subjective to estimating methods and energy modeling to put a dollar figure on benefits such as reduced change orders and potential annual energy savings. Energy price assumptions vary but are stipulated in each study. For instance, the Mills/LBNL study quantified a median savings of $1.24/sf for non-energy benefits (first cost savings plus other benefits such as thermal comfort, IAQ, productivity, equipment life). Whereas the CCC case studies tabulated a median first year cost benefits of only $0.19/sf., and a median annual energy savings of $0.14/sf. While these quantified values may appear nebulous based on different data collection and analysis methodologies, it provides ample evidence of cost savings in new construction commissioning where baseline energy data is not yet available.

Where Steve Doty's study does not supplement this table with costs or payback periods, his findings, opinions, and field experience as a building engineer would be respected by other building professionals involved in Cx. His rationale for cost savings is very clear, although some assumptions could be researched and documented in greater depth. (He alluded to this fact in an interview with the authors of this Task 3 report.) It points out the need to keep a detailed database of issues/deficiencies and measures during Cx and try to apply credible assumptions and estimates for establishing avoided costs or energy savings at the time of documentation.

4.0 DGS Commissioning Experience

Commissioning practice within DGS has increased over the last few years after Executive Order S-20-04 was passed, requiring LEED certification on all State buildings over 10,000 sf. Some of these projects use the "enhanced credit" which allocates an extra point toward the LEED rating and requires Cx to start during design review and continue 10 months after occupancy.

Several DGS personnel were interviewed to discuss their Cx experience. Most found the process to be beneficial, especially if Cx was started early in the project and consistency was maintained from start to finish. All agree that training of building operators and engineers with the Building and Property Management Branch was invaluable, especially if personnel were assigned to the facility during functional testing.

One DGS/BPM engineer commented (regarding the Butterfield/DOR project), "There is a definite "lip service" that is given to the Cx process by contractors, while not fully embracing it… There appears to be a disconnect between what DGS/AEC's vision and understanding are of a holistic Cx program, versus the contractor's view that Cx = Start Up (even though it is pretty clearly defined in the Request For Proposal)."

The former Project Director (Teresa Kaneko) for the Capital Area East End Complex, completed in 2004, believes that Cx works better in a design-build versus bid project, since team cooperation and increased communication/coordination is already integral to the design-build process. On her project, in particular, the general contractor hired the Cx Authority directly. While the Authority did their job of testing and reporting, it was critical that she drove the Cx process as the owner. Having good inspectors within DGS was critical to the success of Cx, as well.

When asked whether DGS should take on Cx activities as Authorities (similar to the work being done by third-parties now), versus just having Cx managers within DGS, she was concerned with in-house Cx Authorities keeping up with training and technologies, especially with building automation systems. She believes it would be more beneficial to have Cx managers help other DGS staff oversee Cx on their projects and "guide the standard" for Cx. Housing Cx within BPM would be most effective. Cx manager(s) could work with other DGS branches, as well as facilitate knowledge and information exchange with other State agencies (i.e. the California Energy Commission)."

Third-party Cx cost data was not provided to evaluate past and current spending by DGS on Cx of their new construction projects. This would be a valuable exercise to ascertain if cost of third party Cx per square foot is congruent with the CCC database and cost-benefit studies discussed in this report. This would provide further justification for funding Cx staff within DGS/BPM during the Capital Outlay Budget Change Proposal process.

5.0 Commissioning Pilot Study (New CALTRANS District 3 Office, Marysville, CA)

Architectural Energy Corporation (AEC) was retained as the Cx Authority for the construction of the new CALTRANS District 3 Office Building in Marysville as part of this study. This is a five-story, 230,000 sf structure with packaged roof-top mechanical units. Schematic design began in 2004 and was finalized for the Request for Proposal (RFP) in early 2006. Proposals were submitted that summer, and Turner/ACMP was awarded the contract. AEC started Cx by performing design review in both the schematic design phase (in 2005) and the construction document phase (second half of 2006). Construction started in the summer of 2007, and Cx escalated again in May, 2008 as equipment installation commenced.

This project is attempting to obtain a LEED Silver certification, and one of the LEED credits includes Energy and Atmosphere Credit 3 (EAc3), Enhanced Commissioning. This credit requires additional design review by the Cx Authority, development of a systems manual, and a review of systems/operation after approximately 10 months of occupancy. AEC performed design review during the early construction document phase of design. This review verified that Turner/ACMP's proposal met or could meet the Basis of Design, Title 24 Guidelines, and applicable LEED credits. In some cases, AEC made recommendations for equipment or system modifications to improve energy performance or system operation.

Starting in May, 2008, a database of issues was created to compile cost/benefit data during submittal reviews, job-site inspections, and functional performance tests (FPTs). This database is titled the "Deficiencies and Measures Log" and is provided in Appendix B. It documents a total of 53 issues and provides further clarification and potential problems communicated by either AEC's Cx Authorities or on-site staff from the Building and Property Management (BPM) branch of DGS.

This project was unique and fortunate to have BPM staff assigned to the project during construction. Wes Hubbart, the building manager, started to attend weekly project meetings in November, 2005. He lives close to the facility and had hoped to be transferred upon the building completion. Hence, he was permitted to become involved to a certain extent very early in the process, but not early enough and to a level that would have added critical value in such areas as space planning for facilities maintenance activities. As a result, it was necessary to lease storage space 20 minutes off site for certain maintenance supplies.

BPM personnel Wes Hubbart, chief engineer Rich Langley, and stationary engineers were assigned full-time to the site starting in July, 2008. However, Caltrans, not DGS, covered their salaries; thus the BPM personnel therefore were not "officially" on site as DGS stakeholders in the oversight and review of the construction process. Consequently, issues of concern presented by BPM to the PMB Project Director (PD) and management consultant (Jacobs Engineering) were not always addressed. Nevertheless, to a significant degree and to a certain level of success, BPM staff was able to work on-site daily along side of Turner, Jacobs, and the subcontractors installing equipment and systems that BPM will be responsible for operating and maintaining for decades to come. They detected a majority of the deficiencies during daily

inspections, whereas AEC was able to identify additional deficiencies and items that needed clarification during submittal reviews and functional performance testing. As the date for occupancy neared, the PD and the construction teams became more responsive to issues and deficiencies brought to the table by BPM. Had there been more responsiveness to BPM input earlier, issue identification and resolution would have been considerably more effective, saving significant time and cost.

6.0 Results of Marysville Pilot Study

It was apparent that in the six months leading up to the occupancy of the building on December 8, 2008 that the combined Cx effort by AEC and the on-site BPM building engineers was invaluable to improving both the immediate and future operation of the building's mechanical, lighting, and control systems, despite the difficulties and problems associated with BPM's being accepted and acknowledged as stakeholders as discussed in Section 5 above. Effectiveness in Cx translates into greater occupant satisfaction, reduced warranty and maintenance issues, and a more successful project delivered by DGS's Project Management Branch. BPM engineers were able to form a mutually beneficial working relationship with ACCO (the mechanical contractor), NABCO (the testing and balancing, TAB, contractor), and Siemens (the controls contractor) to identify and remedy problems on-the-spot and reduce call-backs during the warranty period. While AEC identified potential system shortcomings during submittal reviews and operational problems during FPTs, the daily DGS field inspection and collaboration with the contractors added enormous benefit to the Cx process.

A crucial point to be made is that had BPM been instituted as full stakeholders and engaged much earlier in the design and construction phases, several issues in design errors and installation deficiencies could have been avoided, minimizing or preventing the issues ultimately found by AEC and BPM and subsequently remediated.

The Deficiencies and Measures Log (see Appendix B) generated between May and early December, 2008 lists 53 Cx issues identified by AEC and BPM. Twenty of these issues were further defined as "Deficiencies" and are summarized in Table 4; a complete report including photos is provided in Appendix C. Here, each deficiency is described in detail along with measures taken to remedy the problem and associated cost (if applicable). Costs were categorized as follows:

- Avoided first cost (totaled $101,432): Cost that could have been avoided by contractors had they been identified earlier during construction, design or submittal review. While some of these costs are not necessarily avoided change orders (hence no extra cost to DGS/Caltrans), they could have saved time and improved responsiveness from the contractors involved.
- Avoided future one-time cost (totaled $39,912): Costs that could have been incurred in the future to remedy the problem had it not been identified during construction phase Cx.
- Avoided future annual cost (totaled $46,047 annually): Costs associated with periodic repair or maintenance or energy costs that could have been (or were) avoided with a design or installation change.

A Cost Estimation Assumptions and Details spreadsheet is also provided in Appendix C to illustrate the assumption of hours, rates, and materials for each cost provided.

Table 4: Deficiencies and Associated Costs, Caltrans Marysville Project

No.	Deficiency	Avoided First Cost	Avoided One-time Future Cost	Avoided Annual Future Cost
1	Avoid heat pump valve failure causing heating in electrical rooms	$0		
2a	Improve access to equipment	$2,220		
2b	Remove/replace equipment for access post-occupancy		$4,452	
2c	Additional hours annually for poor equipment access			$2,688
3	Trap primers may fail; provide access for future	$0		
4	Extend exhausts too close to OA intake	$1,828		
5	Heighten boiler stacks to prevent short-circuiting and boiler damage	$1,468		
6	Improve access to 5 fire dampers	$3,380		
7	Add condensate plans to heat pumps	$1,260		
8	Extend waste vent stacks	$820		
9a	Isolate copper piping from cooling tower and Petra AHUs	$1,840		
9b	Isolate CW piping from cooling tower and pumps	$2,760		
10	Install missing return air pathways	$1,160		
11	Purchase manlift and storage room in lieu of catwalks	$50,000		$2,700
12	UPS in data room noise level of 85db; occupancy issues	$0	?	?
13	Replace cooling tower water treatment system		$35,460	
14	Add outlet for garbage disposal	$398		
15	Regular cleaning of structure due to pigeon roosting			$5,780
16	Reroute HVAC ducting and eliminate short-circuiting	$3,000		
17	Lease off-site storage space and added off-site and on-site hours			$30,000
18	Cooling tower CW pump VFD changes: energy cost savings			$3,283
19	Additional cleaning of decorative architectural elements			$1,596
20	Add hopper rooms to each floor	$31,298		
	TOTALS	**$101,432**	**$39,912**	**$46,047 Annually**

Deficiency #12, excessive noise from the uninterrupted power system (UPS), was not assigned a cost. This noise problem had not been resolved as of this report completion. The manufacturer's representative from Liebert met with DGS and Caltrans Information Technology (IT) personnel in early December, 2008 to address the problem. After some initial adjustments, the noise level only dropped 3 to 4 decibels (dB) below the initial reading of 85db. If this noise issue is not resolved, the cost implications can vary. Replacement of the UPS is expensive but may be able to be negotiated with the manufacturer. Two to four IT personnel work full-time in the data room. DGS's Environmental Safety and Health Operations Program (ESHOP) requires hearing protection for workers exposed to greater than 85dB for an 8-hour period. In addition, the worker in the cubicle directly below the data center is being exposed to 57dB, similar to a constant, loud hum. Hence, working conditions in these spaces are sub-standard and will likely affect productivity. In the short-term, workers in these areas may need

to be temporarily relocated until the issue is resolved. Future Requests for Proposal should specify a decibel limit for all UPS systems (and others that potential create excessive noise) which can be verified (prior to purchase and installation) in the submittal review process of Cx.

Another valuable point was made by Wes Hubbart of BPM regarding pursuing LEED-Exiting Building (EB) certification in the future. (One of the resolutions in the Governor's Green Building Initiative requires all existing State buildings larger than 50,000 sf to meet LEED-EB building standards to the maximum extent that is cost effective by no later than 2015.) This is much easier to attain if enhanced metering and monitoring capabilities are provided during construction when it's much simpler, easier and more cost effective than retrofitting equipment in the future. Adding these capabilities, especially to the energy management and building automation systems, allows BPM operators to provide load shedding and run energy use reports, ultimately allowing greater flexibility and ability to manage energy consumption.

It should be noted that there were many other undocumented repairs and modifications that occurred because of BPM oversight during construction. This report attempts to capture the majority of issues, but there are many others that undoubtedly were exposed and remedied. It is realistic that in-frequent site visits by the Cx Authority (as compared to the daily presence of 5 BPM staff) would not have captured all of the issues.

BPM staff will continue to work with these subcontractors during the 12-month warranty period ahead. This is notoriously a problematic process as contractors have been paid substantially and have moved on to new projects. The fact that the BPM operators and engineers have established relationships with these subcontractors, the warranty period is likely to see fewer callbacks and increased cooperation.

7.0 Statewide Costs and Benefits

7.1. Construction Forecast

The projections for California State Agency's "Green Buildings" (including LEED rating of existing buildings) as of October, 2008 can be found at http://www.greenbuildings.dgs.ca.gov. From this list, a total of 78 projects (encompassing 234 buildings) are new construction and are in one of the five phases ranging from acquisition to construction. This represents a total of approximately 6.2 million square feet to be commissioned under LEED. A spreadsheet of these new construction projects is provided in Appendix D.

7.2. Commissioning Cost

This Task 3 report literature review shows that the cost of new construction Cx ranges from $0.85 to $1.10/sf. AEC's cost to Cx the Marysville project was approximately $135,000, or $0.59/sf. (This budget was established in 2005.) The Task 2 report, based on State construction projections for 2006, demonstrated that 7,787 hours per year for Cx Authorities would be required to take on the project load (approximately 3.8 million sf) at that time. Direct extrapolation for the current projection of 3.3 million sf (39 projects either under construction or in the "working drawings" phase) would modify this estimate to 6,800 Cx Authority hours per year. Assuming 1,600 hours per year are available for project work, four new Cx staff-persons would be required. At an assumed average annual salary, benefit, and overhead cost to DGS of $150,000 per person, this would require additional funding of $600,000 for four new DGS Cx personnel.

Based on a conservative Cx cost of $0.85/sf as demonstrated in this Task 3 report, approximately $2.8 million could be spent on commissioning for these 39 projects. As the Task 2 report explains, DGS staff may not be involved in Cx of all projects, especially those that are more complex. However, this contrast in cost of additional staffing versus third-party Cx suggests that bringing Cx into DGS services has a significant potential for cost savings.

7.3. Commissioning Benefit

As discussed in the Literature Review section, quantification of benefits in new construction has been limited. Two studies calculated median values for all non-energy benefits ($1.24/sf savings), solely first year cost benefits ($0.19/sf), and annual energy savings ($0.14/sf and $0.05/sf). Hence, the range of total energy and non-energy benefit for new construction Cx was calculated at $0.33 to $1.29/sf. Again, it must be stressed that these values represent a small sampling and various methodologies.

The total quantified benefit of Cx on the Caltrans Marysville project was a one-time cost avoidance of $141,344 ($0.61/sf) and $46,047 annually ($.20/sf annually).

Taking the most conservative benefit value of $0.33/sf and applying it to the projected 6.2 million square feet of new State buildings to be commissioned, this represents a potential

benefit of over $2.0 million. (Or in the near-term, considering just those projects under construction or in the working drawings phase, the benefit becomes almost $1.1 million based on the nearly 3.3 million sf of project area.) Realizing the cost/sf benefit that was most recently achieved at the Caltrans Marysville project ($0.76/sf in the first year), this 3.3 million sf of project area could see a total benefit of nearly $2.5 million.

8.0 Conclusions and Recommendations

The research and case study on the cost and benefits of commissioning provided herein justify establishing commissioning positions within DGS and providing project funding for commissioning. There is ample evidence of substantial tangible (cost savings) and non-tangible (productivity and improved relations) benefits of involving engineers and operators from the Building and Property Management branch (BPM) to commission projects, starting as early in the design process as possible. This would provide retention of valuable lessons learned within BPM and the Design Services Section (DSS) of the Professional Services Branch (PSB) as well as accountability to those BPM staff responsible for maintaining and operating these facilities for many years to come.

The review of previous research papers and the California Commissioning Collaborative's project database demonstrated a range of Cx cost per square foot of $0.85 to $1.10 for new construction. As a percentage of construction, Cx cost 0.4% to 1.2% of the project construction cost. At Marysville, Cx cost $0.59/sf, representing 0.21% of the construction costs.

Benefits of Cx of new buildings are often difficult to quantify because there are no energy-use benchmarks, occupant or operator satisfaction studies, or consistent measures to compare issues and costs. Previous research suggests that benefits range from $0.33 to $1.29 per square foot. Benefits of Cx on the Caltrans Marysville project included a one-time cost avoidance of $141,344 ($0.61/sf) and $46,047 (0.20/sf) annually.

Numerous DGS managers, engineers, and operators were interviewed or consulted for their opinions of the Cx process and consideration to housing these services internally (especially within BPM) versus hiring third-party Cx Authorities. It was unanimous that Cx brings ample value to DGS projects, and involving building operators in the early stage of design of larger projects is crucial. Cx staff should reside in BPM where their skills and experience lend the most value to the process and their (post-occupancy) operations will receive the greatest benefits.

Based on 2008 projections for new State construction projects, 4 additional BPM staff-members could manage the 3.3 million sf (projects either under construction or in the "working drawings" phase) of new construction Cx. Assuming an average annual salary, benefit, and overhead cost to DGS of $150,000 per person, this would require additional funding of $600,000 for the four new DGS Cx staff positions. Based on the benefit value tabulated from the Marysville case study ($0.76/sf in the first year, near the average $/sf benefit value derived from the literature review), this 3.3 million sf of project area could see a total initial benefit of nearly $2.5M.

Finally, it should be noted that these results will be contributed to the ongoing Cx cost-benefit study and meta-analysis by Evan Mills of Lawrence Berkeley National Labs, to be finalized in early 2009.

Integrating Building Commissioning into State Building Construction

Appendix A: Summary of Commissioning Collaborative Case Studies

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
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Arnold Schwarzenegger, *Governor*

Subtask 3.0 Deliverable

CALIFORNIA ENERGY COMMISSION

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THE COST-EFFECTIVENESS OF COMMERCIAL-BUILDINGS COMMISSIONING

A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States

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An electronic version of this document and data input forms are available at
http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html

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Table 7. Results summary with quartile analysis: Existing buildings.

	Units	Number of projects	Min	Bottom 25%	Median	Average	Top 25%	Max
Commissioned floor area	ft^2	106	5,690	95,101	**151,000**	209,729	271,650	1,014,133
Commissioning Costs								
Total	$2003/building	102	3,214	26,112	**33,696**	46,442	45,862	476,554
Normalized - excluding non-energy impacts, NEIs*	$2003/$ft^2$	102	0.03	0.13	**0.27**	0.41	0.45	3.86
Normalized - only for cases including non-energy impacts, NEIs*	$2003/$ft^2$	11	-0.27	0.04	**0.17**	0.41	0.45	1.88
Cx agent fee as percentage of total commissioning fee	%	9	32%	35%	**67%**	57%	71%	76%
Costs paid by:								
Building owner	%	31	0%	32%	**50%**	47%	50%	100%
Utility (e.g. as rebate)	%	48	20%	50%	**84%**	75%	100%	100%
Other (e.g. research grant)	%	7	33%	100%	**100%**	90%	100%	100%
Utility rebates (included in above costs)	$2003/building	48	917	11,932	**20,500**	23,685	25,000	76,725
as % of total costs	%	48	20%	50%	**84%**	75%	100%	100%
Deficiencies								
Per building	Number/building	85	0.7	5.0	**11**	32	21.0	640.0
Per 100kft2	Number/100kft^2	85	0.1	2.8	**6**	24	18.3	225.6
Measures								
Per building	Number/building	75	1.0	4.5	**9.0**	20.3	18.0	481.0
Per 100kft2	Number/100kft^2	66	0.1	2.5	**5.9**	8.6	12.7	218.6
Total Energy Cost Saving								
Raw data (mixed energy prices and years)	nominal $/building-yr	100	-25,752	11,739	**33,629**	66,489	75,940	879,101
Local energy prices	$2003/building-yr	100	-26,595	13,351	**37,376**	75,393	80,615	1,034,667
Standardized US-average energy prices	$2003/building-yr	57	-39,043	14,646	**44,629**	105,156	98,708	1,776,371
Percent energy bill savings	%	74	-3%	7%	**15%**	18%	28%	54%
Normalized Energy Cost Savings								
Raw data (mixed energy prices and years)	nominal $/$ft^2$-yr	100	-0.09	0.11	**0.24**	0.42	0.46	3.83
Local energy prices	$2003/$ft^2$-yr	100	-0.09	0.11	**0.27**	0.47	0.52	4.33
Standardized US-average energy price	$2003/$ft^2$-yr	56	-0.13	0.11	**0.26**	0.54	0.72	3.23
Monetized non-energy impacts (one-time)								
Per project	$2003/project (1000s)	10	-281	-31	**-17**	-45	-11	-1
Normalized by floor area	$2003/ft2-yr	10	-0.55	-0.45	**-0.18**	-0.26	-0.10	0.00
Energy Savings								
Electricity	kWh/ft^2-yr	57	-0.70	0.64	**1.7**	2.2	2.76	9.72
Percent savings	%	46	-5%	5%	**9%**	11%	15%	36%
Peak electrical power**	W/ft^2	6	0.1	0.4	**0.6**	0.7	0.8	1.6
Percent savings	%	3	1%	2%	**2%**	7%	9%	17%
Fuel	kBTU/ft^2-yr	29	-14.2	2.3	**6.5**	16.6	13.5	209.5
Percent savings	%	19	-16%	1%	**6%**	13%	23%	67%
Thermal (chilled water, hot water, steam)	kBTU/ft^2-yr	19	6	32	**64**	94	122	356
Percent savings	%	16	13%	23%	**36%**	37%	48%	63%
Total	kBTU/ft^2-yr	57	-15	7	**17.0**	49.3	56	357
Percent savings	%	46	-7%	7%	**15%**	19%	29%	57%
Payback Times [undiscounted]								
Raw data (mixed energy prices and years)	years	99	-1.5	0.4	**1.0**	2.1	2.0	20.7
Local energy prices and inflation-corrected cx costs	years	99	-1.5	0.3	**1.0**	2.1	2.4	26.1
Standardized U.S. energy prices and inflation-corrected cx costs	years	59	-1.0	0.2	**0.7**	1.7	2.1	10.4

* Non-energy impacts (NEIs) include increases or decreases in first or operating costs due to changes in maintenance costs, contractor callbacks, equipment life, and
** Most are averaged over the entire year, hence true "peak" savings are significantly higher than shown here.

Table 8. Results summary with quartile analysis: New construction.

		Number of projects	Min	Bottom 25%	Median	Average	Top 25%	Max
Commissioned floor area	ft^2	69	1,072	32,268	65,500	118,369	151,000	685,000
Commissioning Costs								
Total	$2003/building	69	2,089	19,515	74,267	165,139	218,960	1,126,000
Normalized - excluding non-energy impacts, NEIs*	$2003/$ft^2$	69	0.10	0.49	1.00	1.64	1.66	18.20
Normalized - only for cases including non-energy impacts, NEIs*	$2003/$ft^2$	22	-7.82	-0.27	0.35	0.11	1.22	4.40
As % of construction cost (excl. NEIs) [%]*	%	65	0.1%	0.3%	0.6%	0.9%	1.1%	5.9%
As % of construction cost (incl. NEIs) [%]*	%	22	-5.2%	-0.2%	0.2%	0.03%	0.8%	1.5%
Cx agent fee as percentage of total commissioning fee	%	25	56%	74%	80%	78%	86%	94%
Costs paid by:								
Building owner	%	23	50%	50%	50%	72%	100%	100%
Utility (e.g. as rebate)	%	31	50%	50%	100%	79%	100%	100%
Other (e.g. research grant)	%	2	-	-	-	-	-	-
Utility rebates (included in above costs)	$2003/building	31	2,089	6,542	16,650	27,055	42,677	128,265
as % of total costs	%	31	50%	50%	100%	79%	100%	100%
Deficiencies								
Per building	Number/building	34	2	4	28	67	75	705
Per 100kft2	Number/100kft^2	34	5	16	37	90	81	1,010
Measures								
Per building	Number/building	21	2	3	7	55	30	705
Per 100kft2	Number/100kft^2	22	5	13	20	13	43	285
Total Energy Cost Saving								
Raw data (mixed energy prices and years)	nominal $/building-yr	33	39	362	1,944	22,604	14,628	300,000
Local energy prices	$2003/building-yr	33	46	369	2,288	24,785	14,937	306,344
Standardized US-average energy prices	$2003/building-yr	27	-88	622	2,533	9,226	13,722	61,288
Percent energy bill savings	%	-	-	-	-	-	-	-
Normalized Energy Cost Savings								
Raw data (mixed energy prices and years)	nominal $/$ft^2$-yr	33	0.00	0.02	0.05	0.25	0.13	3.20
Local energy prices	$2003/$ft^2$-yr	33	0.00	0.02	0.05	0.29	0.16	3.84
Standardized US-average energy price	$2003/$ft^2$-yr	30	0.00	0.02	0.05	0.11	0.19	0.44
Monetized non-energy impacts								
Per project	$2003/project (1000s)	22	-1418	-138	-51	-177	-15	17
Normalized by floor area	$2003/ft2-yr	22	-43.93	-6.96	-1.24	-6.11	-0.23	0.43
Energy Savings								
Electricity	kWh/ft^2-yr	29	-0.49	0.20	0.5	1.2	1.36	5.63
Percent savings	%	3	8%	8%	8%	10%	11%	13%
Peak electrical power**	W/ft^2	11	0.0	0.03	0.1	0.2	0.2	0.6
Percent savings	%	-	-	-	-	-	-	-
Fuel	kBTU/ft^2-yr	18	-3.6	0.2	2.2	2.1	3.4	13.5
Percent savings	%	-	-	-	-	-	-	-
Thermal (chilled water, hot water, steam)	kBTU/ft^2-yr	-	-	-	-	-	-	-
Percent savings	%	-	-	-	-	-	-	-
Total	kBTU/ft^2-yr	30	-1	2	3.2	6.2	8	26
Percent savings	%	-	-	-	-	-	-	-
Payback Times [undiscounted]								
Raw data (mixed energy prices and years)	years	39	0.0	1.9	6.5	23.0	19.5	303.1
Local energy prices and inflation-corrected cx costs	years	38	0.0	1.9	5.6	21.9	22.6	175.4
Standardized U.S. energy prices and inflation-corrected cx costs	years	39	0.0	1.2	4.8	14.0	16.6	105.0

* Non-energy impacts (NEIs) include increases or decreases in first or operating costs due to changes in maintenance costs, contractor callbacks, equipment life, and
** Most are averaged over the entire year, hence true "peak" savings are significantly higher than shown here.

Integrating Building Commissioning into State Building Construction

Appendix B: Cost-Benefit Analysis of Commissioning - Deficiencies and Measures

CONSULTANT REPORT

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Prepared By:
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Arnold Schwarzenegger, *Governor*

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CALIFORNIA ENERGY COMMISSION

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Boulder, Colorado
Commission Contract No. 500-04-016

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Commission Contract No. 500-04-016

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CALTRANS Marysville District 3 Offices
Cost-Benefit Analysis of Commissioning: Deficiencies and Measures

Item No.	Date	Identified During*:	By**:	Description	Clarification (C) or Deficiency (D)?
1	5/12/08	SR	AH; AEC	The Building Automation System (BAS) interface w/ Petra roof top units (RTUs) needed more integration for Sequence of Operation (SOO). The SOO was revised on 5/19/08 to address other modes of operation which will be addressed by the Bacnet interface.	C
2	5/12/08	SR	AH; AEC	For the heat pumps in electric rooms, there is a potential for valve failure causing default to heating mode. See Deficiency #1.	D1
3	5/12/08	SR	AH; AEC	The humidification control for Computer Room air conditioning (CRAC) needed to be clarified. Turner reported that the evaporator coil acts as a humidifier. The low latent load in the space does not justify an additional dehumidifier. There will be an onboard thermostat and humidistat in the computer room.	C
4	5/12/08	SR	AH; AEC	AEC expressed concern that there are three different systems (LonTalk, BACnet, and Modbus) that need to be interfaced with main Siemens BAS. Turner responded on 6/3/08 with clarification of the proper interface between the BAS and the Petra air-handling units (AHUs), CRAC and lighting systems.	C
5	5/12/08	SR	AH; AEC	The control schematic for the heat pump condenser valve interlock with compressor was unclear. Turner responded on 6/3/08 that the heat pump units do not have condenser valves. They were deleted to provide a minimum flow capability for the chilled water system.	C
6	5/12/08	SR	AH; AEC	Wiring for fan & compressor control for heat pumps was missing (drawings 403 and 404). This was corrected in a revised submittal.	C
7	5/12/08	SR	AH; AEC	Makeup air units (MUAs), space heaters, and water treatment system control by the BAS was missing in the control schematic. Turner provided the missing drawing 410 and additional clarification for the MUA and space heaters. ACCO to provide BAS controls to the water treatment system.	C
8	5/23/08	FI	RL: BPM	Rich Langley (DGS) also pointed out the issue with potential valve failure in the heat pumps in the electric room. See Deficiency #1.	D1
9	5/23/08	FI	RL: BPM	The heat pump duct for main electric room dead heads into hard-cap ceiling. There are also conflicting routing issues with OTIS Elevator's conduit runs. See Deficiency #16	D16
10	5/23/08	FI	RL: BPM	The heat pump near the front lobby has a 2" gas line in front of an access panel. It later turned out that there was access from another side. DGS recommends checking access to all units. Two examples are provided under Deficiency #2.	D2
11	5/23/08	FI	RL: BPM	Rich Langley noted that a variable air-volume (VAV) box on the north side of the 2nd floor has a damper actuator with poor access; it's located right up against a wall. See Deficiency #2.	D2
12	5/23/08	FI	RL: BPM	Low volume lavatory fixtures may not prime trap primers. DGS recommends changing to constant drip primers (that are being considered on the Department of Revenue project). See Deficiency #3.	D3
13	5/23/08	FI	RL: BPM	Supply and return ducts were blowing right into a wall causing the air flow to short cycle. The ducts were reconstructed to turn down below the wall and the filter rack was installed at the end of the return duct opening. (This also alleviated the filter access issue on the other side of the wall, where the filter compartment was obstructed by an electrical trough.) See Deficiency #16.	D16
14	6/2/08	SR	AH; AEC	The SOO for Petra AHUs does not mention night cool-down, heating, or cooling sequences. Verification of these modes of operation was requested by AEC. Turner responded on 6/18/08 that all of those modes will be implemented by Siemens as hybrid modes (with additional detail).	C
15	6/2/08	SR	AH; AEC	Rooftop unit AC-5 is not equipped with an outside air (OA) flow station. If demand control ventilation for AC-5 (serving the café') is still required, the OA damper shall be overrrode and opened to maximum position via the BAS when the space CO2 level is above setpoint. Turner confirmed on 6/18/08 that this condition will be programmed in the Siemens control system.	C
16	6/2/08	SR	AH; AEC	AEC requested that the staging control for chilled water (CW) pumps 1-3 be amended. Turner responded on 6/18 that ACCO and Siemens prefer the original sequencing and that a meeting should be scheduled to discuss the optimum sequencing.	C
17	6/2/08	SR	AH; AEC	AEC notes that a heating hot water (HHW) temperature reset strategy was not implemented for the HHW setpoint in the SOO. Turner responded on 6/18/08 that Title 24 does not require HHW temperature reset for this variable flow system.	C
18	6/26/08	FI	RL: BPM	On the roof of the Café, the MUA unit is installed with the intake less than twelve feet from the cafe hood exhaust fan. This will recycle the exhaust hood fumes back into the Café on cold mornings. See Deficiency #4.	D4
19	8/4/08	FI	RL: BPM	The three Pennant package boilers are installed with only about six foot high exhaust stacks and are installed about thirty feet from the OA intake for one of the Petras AHUs. On cold mornings this would draw the boilers exhaust fumes into the building. It also could cause condensation in the exhaust pipe, causing water to drain down and corrode the top plates of the boilers. See Deficiency #5.	D5
20	8/4/08	FI	RL: BPM	In several places, exhaust vents and waste stacks are located too close to the outdoor air (OA) intakes of the Petra RTUs. Stacks should be moved or more likely extended to prevent building exhaust or sewer gas from being drawn back into the building. See Deficiency #8.	D8
21	8/19/08	FI	RL: BPM	DGS reported that when the Petra AC unit #2 was turned on, workers in the 2nd floor open office area could smell sewer gas. This odor was also distinct at the outdoor supply air intake to the unit. The nearby sewer stacks are not high enough. See Deficiency #8.	D8

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22	9/9/08	FI	WH: BPM	During the design phase, BPM lost 2000 sf of building space that had been delegated for attic stock storage. The space got reassigned to Caltrans program space. Because of this, BPM had to procure long-term lease storage space off-site. In addition, hopper rooms were designed so small (3ft x 5ft) that they will have to store all products in a 1st floor storage space. See Deficiency #17	D17
23	9/9/08	FI	WH: BPM	RFP language only called for one hopper room per floor as the original design designated one central restroom and elevator core. However, this changed to two restroom cores during the design and proposal process. However, a second hopper room was never added. It was later incorporated during construction as a change order. See Deficiency #20	D20
24	10/16/08	FI	AH; AEC	The photocell controlling external lighting (on the lower, 4th level roof) is pointing west instead of north; orientation to be adjusted. In the west orientation, higher lighting levels (as compared to north) might be detected late in the day, potentially delaying the operation of exterior lights.	C
25	10/16/08	FI	AH; AEC	The 5th floor electric room heat pump unit is missing the air duct and diffuser.	C
26	10/16/08	FI	AH; AEC	Canyon ceiling lighting is not uniform; light louvers should be adjusted to achieve uniform light distribution.	C
27	10/20/08	FI	RL: BPM	Rich Langley sent an email to Richard Myren (DGS Project Director) indicating that the BAS is not fully integrated with the Petra HVAC system and Café' exhaust fans. Maintenance personnel will not have control of the energy management systems (EMS), with results of wasted energy and negative static pressure which also could cause water damage during rainy weather. Derek Kmicikiewicz of the AEC Cx team resolved part of this issue by confirming with Siemens the 6 modes of operation that controls supply air temperatures. The EMS for the cafe still needed to be programmed.	C
28	10/20/08	FI	RL: BPM	Five Belimo fire dampers had such poor access or were blocked by sprinkler heads that they could never be annually inspected or repaired. Dampers were modified and/or access was improved. See Deficiency #6.	D6
29	10/20/08	FI	RL: BPM	DGS recalled a problem on a previous project with fire actuated roll-down doors that separate the offices from the atrium. In this previous case, the sensor that signals for the doors to close was falsely tripped by a floating obstruction. When the doors came down, they fell hard and fast. Rich Langley confirmed that these doors drop slower and are not as prone to sensor obstructions. He did note, however, that the 14" square access in the hard cap ceiling is barely enough access to get into the motor operators for maintenance. See Deficiency #2.	D2
30	10/20/08	FI	RL: BPM	Over the mail room, the two heat pumps have no condensate pans. It possible this equipment and piping could sweat causing condensation to saturate and damage the drop ceiling and whatever else lies beneath each pump. See Deficiency #7.	D7
31	10/20/08	FI	RL: BPM	While the cooling towers have spring dampers for vibration, the attached piping does not have isolation fittings. Two consequences include potential pipe damage from friction at the tower/piping interface, and vibration through non-isolated equipment will telegraph into the structure. See Deficiency #9.	D9
32	10/20/08	FI	RL: BPM	At the executive suite on the 4th floors, there are 3-4 private offices that were only provided with 10" square return air diffusers. On average, the return plenum AHU is located approximately 50 feet from each office diffuser, versus only about 20 feet to a return diffuser in the adjacent hall and canyon area. Hence, it is likely that the return air path of least resistance will be via the hall/canyon, and when these office doors are closed, they will not be circulating sufficient return air and overheat. See Deficiency #10.	D10
33	10/20/08	FI	RL: BPM	In the canyon area, access to light fixtures will be very difficult for changing bulbs. This is also an issue at the entry way where artistic lattice-work was installed over the neon light fixture back-lighting the slats. These slats will need to be disassembled to access the fixture for maintenance and cleaning. See Deficiency #11.	D11
34	10/20/08	FI	RL: BPM	The cooling fan on the UPS in the data center is very loud; RL took a reading of 85-88 dB. Hence, per OSHA requirements, anyone working in the data center has to wear hearing protection. In addition, this noise transfers down to the 4th floor, specifically four cubicle workstations below. A 57 dB reading was taken here (where it sounds like a loud hum of a transformer). The unit has been adjusted but with only minor dB reductions. Troubleshooting ongoing and resolution TBD. See Deficiency #12.	D12
35	10/20/08	FI	RL/WH: BPM	BPM pointed out that the steel entry structure is going to attract lots of pigeons (from experience on the Franchise Tax Board project) and create an extra demand for cleaning. On FTB, they had to pressure wash the glass and re-apply the product "Bird-X" or "Hot-Feet" that irritates the birds' feet and discourages roosting. See Deficiency #15.	D15
36	10/20/08	FI	RL: BPM	The Computer Room floor is lacking an underfloor drain and water sensor. The condensate pans to the CRAC units have pumps. However, should these pumps fail, there would be no way to know that water was starting to accumulate. BPM will likely purchase/install a simple, stand-alone water detection/alarm device during the warranty period (less than $30).	C
37	11/14/08	FI	RL/WH: BPM	The city water in Marysville contains a count of 500-600 mg/L total dissolved solids (TDS), as compared to a normal range of 150-200 mg/L for municipal water supplies. With this high solids loading, DGS estimates they will spend $32K to $40K annually for chemicals. A Dolphin chemical-free system could have been purchased and installed for less than this cost, but the system was eliminated during value engineering. See Deficiency #13.	D13
38	11/14/08	FI	RL/WH: BPM	DGS discovered that an outlet for a kitchenette garbage disposal was not installed in the sink cabinet. Rich Langley happened to switch on the disposal to test it and discovered the missing outlet. See Deficiency #14.	D14

Item No.	Date	Identified During*:	By**:	Description	Clarification (C) or Deficiency (D)?
39	11/14/08	FI	RL/WH: BPM	DGS building engineers identified several design decisions that will add to routine maintenance and cleaning. 1: Turner/ACMP proposed and installed exposed ducting, which will require additional routine cleaning on ladders. 2: Decorative slats were installed over neon light fixtures in the main lobby. Every time these fixtures need to be dusted or changed, these slats will require removal, separate cleaning, and replacement.	D19
40	11/20/08	FPT/Cx	AH; AEC	Two cooling tower isolation control valve actuators were discovered to be burnt out. Siemens to replace these by 11/21.	C
41	11/20/08	FPT/Cx	AH; AEC	OA dampers were observed to be in minimum position when the AHUs were in warm-up mode. These dampers shall reset to fully closed position instead to speed up the warm-up process. BAS programming was adjusted 11/21.	C
42	11/20/08	FPT/Cx	AH; AEC	Hot water control valves on Petra AHUs remained open after the heating sequence ended. The Petra representative identified that control wiring to valve actuators was not correct and made the repair immediately.	C
43	11/20/08	FPT/Cx	AH; AEC	Petra AHUs would not always go to warm-up mode when commanded by the Siemens BAS (under simulated conditions). Petra and Siemens resolving.	C
44	11/20/08	FPT/Cx	AH; AEC	The actual flow rate of primary chilled water pumps CWP-1, 2, and 3 were much higher than designed values, causing the balancing valves to over-close. Siemens adjusted the VFD speed of smaller CWP-3 and ramped down the larger pumps to 30 and 32 Hz to avoid overcooling of the building and CW loop, ultimately saving energy. See Deficiency #18.	D18
45	11/20/08	FPT/Cx	AH; AEC	The Liebert CRAC units were controlled by Liebert's high level interface. Only operation status and parameters were provided to the Siemens BAS. ACCO and Siemens shall ensure continuous CRAC operation whenever the CW supply is switched over from the cooling towers (CTs) to Drycoolers (DC).	C
46	11/20/08	FPT/Cx	AH; AEC	The graphical user interface screens for VAVs, heat pumps, and exhaust fans (EFs) were not completed; Siemens to add by 12/2.	C
47	11/21/08	FPT/Cx	AH; AEC	The make-up air unit was not interlocked with the kitchen exhaust fan EF-7. ACCO and Siemens to verify interlock wiring by 12/2.	C
48	11/25/08	FPT/Cx	AH; AEC	The building static pressure sensor reads +0.036 inches w.c. (and it should be +0.05), while ACCO's measurements indicate that the pressure is negative. All of these sensors should be calibrated and the speed controls of the Petra fans verified.	C
49	11/25/08	FPT/Cx	AH; AEC	Petra AHUs 3 and 4 failed due to high supply air (SA) pressure alarm. It appears that there were problems with sensor calibration and VAV damper operation and the problem was remedied.	C
50	11/25/08	FPT/Cx	AH; AEC	CRACs were tripped due to a high compressor pressure alarm. Drycooler CW valve 2 failed to switch over to the Drycooler position (it remained in the CT position). ACCO/Siemens to test and verify that both DC CW control valves can switch smoothly between CT and DC. Loss of CW flow will result in CRAC unit shutdown. Butterfly valve positions must be clarified, and a valve opening delay to DCV-1 is recommended to help delay back pressure on DCV-2 and make operation smoother.	C
51	11/25/08	FPT/Cx	AH; AEC	No alarm was generated when DC CW flow had not been confirmed after the CRAC system was switching from CT to DC for more than 5 minutes. An alarm indicating "No CW flow" must be programmed for DC operation by Siemens by 12/8/08.	C
52	11/25/08	FPT/Cx	AH; AEC	Cooling tower loop balancing must performed with two CTs on for large pumps and one CT on for the smaller pump. AEC did not see balancing valves on cooling tower and building loop pumps. See Deficiency #18.	D18
53	11/25/08	FPT/Cx	AH; AEC	HHW system bypasses were set at 40 GPM when all reheat valves were closed. AEC identified that these VFD pumps should dial back when demand falls to save energy and allow for enough capacity when most of the reheat valves open, both achieving a setpoint of 8 psi. Hence, AEC directed NABCO to reduce the bypass flow to 20 GPM by adjusting some of the by-pass circuit setters to 0 GPM by decreasing the number of end-of-loop by-passes from four to no more than two.	C

* SR: Submittal Review, FI: Field Inspection, Cx: Commissioning, FPT: Functional Performance Test
** AH; AEC: Alex Ho, Architectural Energy Corporation
** RL/WH/BPM: Rich Langley and/or Wes Hubbart, Building Property Management branch of DGS

Integrating Building Commissioning into State Building Construction

Appendix C: Cost-Benefit Analysis of Commissioning - Cost Estimation Assumptions & Details

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
December 2008

Arnold Schwarzenegger, *Governor*

Subtask 3.0 Deliverable

CALIFORNIA ENERGY COMMISSION

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Cost-Benefit Analysis of Commissioning: Deficiencies and Measures
Cost Estimation Assumptions & Details

Def#	Brief Description	Labor Category	Hours	Rate	Total	Avoided First Cost	Avoided One-time Future Cost	Avoided Annual Future Cost
2a	Poor equipment access:	Sheet-metal Workers	16	$55	$880			
	Rotate/flip/adjust VAVs, move	Pipefitter/plumber	16	$65	$1,040			
	gas and sprinkler piping	Materials			$300			
		Total, Deficiency #2a			**$2,220**	$2,220		
2b	Poor equipment access:	Sheet-metal Workers	48	$55	$2,640			
	Cut out, R&R VAV in future	Electrician	4	$58	$232			
		Drywaller/Acoustic Ceiling	16	$55	$880			
		Materials			$700			
		Total, Deficiency #2b			**$4,452**		$4,452	
2c	Poor equipment access:	BPM Maintenance Mechanic	48	$56	$2,688			
	Additional hours annually							
		Total, Deficiency #2c			**$2,688**			$2,688
4	Exhausts close to OA intake	Carpenter	8	$56	$448			
	(including added supports)	Sheet-metal Worker	16	$55	$880			
		Materials			$500			
		Total, Deficiency #4			**$1,828**	$1,828		
5	Boiler exhausts too short	Boiler technician	8	$65	$520			
	(including added supports)	Carpenter	8	$56	$448			
		Materials (assume Scope)			$500			
		Total, Deficiency #5			**$1,468**	$1,468		
6	Improve access to 5 fire dampers	HVAC technicians	48	$60	$2,880			
		Materials			$500			
		Total, Deficiency #6			**$3,380**	$3,380		
7	Add condensate plans	HVAC technicians	16	$60	$960			
		Materials			$300			
		Total, Deficiency #7			**$1,260**	$1,260		

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8	Extend waste vents	Pipefitter/plumber	8	$65	$520			
		Materials			$300			
		Total, Deficiency #8			**$820**	$820		
9a	Isolate copper piping from cooling	Pipefitter/plumber	16	$65	$1,040			
	tower and RTUs	Technician/helper	16	$50	$800			
	(Added time to do after-the-fact)	Materials (incl in contract)			$0			
		Total, Deficiency #9a			**$1,840**	$1,840		
9b	Isolate CW piping from cooling	Pipefitter/plumber	24	$65	$1,560			
	tower and pumps	Technician/helper	24	$50	$1,200			
	(Added time to do after-the-fact)	Materials (incl in contract)			$0			
		Total, Deficiency #9b			**$2,760**	$2,760		
10	Additional RA pathways	HVAC technicians	6	$60	$360			
		Drywaller/Acoustic Ceiling	16	$55	$400			
		Materials			$400			
		Total, Deficiency #10			**$1,160**	$1,160		
11	Purchase manlift for maintenance	Cost of manlift	1		$87,000			
	vs. catwalk + storage room	Deduct cost for catwalk	1		-$37,000			
		Total, Deficiency #11			**$50,000**	$50,000		
	Added annual maintenance time	Building Maintenance Workers	60	$45	**$2,700**			$2,700
13	Replace cooling tower water	Remove existing system	32	$55	$1,760			
	treatment system	Purchase Dolphin system			$30,000			
		Install Dolphin system	40	$55	$2,200			
		Misc. Materials			$1,500			
		Total, Deficiency #13			**$35,460**		$35,460	
14	Add outlet for garbage disposal	Electrician	6	$58	$348			
		Added materials			$50			
		Total, Deficiency #14			**$398**	$398		

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Def#	Brief Description	Labor Category	Hours	Rate	Total	Avoided First Cost	Avoided One-time Future Cost	Avoided Annual Future Cost
15	Cleaning of structure due to	Building Maintenance Workers	64	$45	$2,880			
	pigeons (calculated annually)	Rent manlift	4	$400	$1,600			
		Bird-X Material	4	$200	$800			
		Misc. Materials for Cleaning			$500			
		Total, Deficiency #15			**$5,780**			$5,780
16	HVAC routing and	Sheet-metal Worker	16	$55	$880			
	short-circuiting	Drywaller/Acoustic Ceiling	24	$55	$1,320			
		Materials			$800			
		Total, Deficiency #16			**$3,000**	$3,000		
17	Lease off-site storage and added	Monthly lease (avg. until 2013)	12	$1,600	$19,200			
	daily time to access (including 1st	Custodian, added off-site time	200	$36	$7,200			
	floor storage only)	Custodian, added on-site time	100	$36	$3,600			
		Total, Deficiency #17			**$30,000**			$30,000
18	Reduced CW Pump 1-3 power	CWP1: 15,040 KWh/yr			$1,805			
	Assumes 30% savings by reducing	CWP2: 7,520 KWh/yr			$902			
	VFD for proper flow, $0.12/KWh	CWP3: 4,800 KWh/yr			$576			
		Total, Deficiency #18			**$3,283**			$3,283
19	Additional cleaning of	Custodian Supervisor	8	$43	$344			
	decorative elements	Custodian	32	$36	$1,152			
	(Assumes ducts and lattice	Materials			$100			
	cleaned 4x per year)	**Total, Deficiency #19**			**$1,596**			$1,596
20	Added hopper rooms	Lump Sum (per DGS/BPM)			$31,298			
	(change order during construction)							
		Total, Deficiency #20			**$31,298**	$31,298		
		TOTAL Avoided Costs			**$187,391**	**$101,432**	**$39,912**	**$46,047**
								Annually

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Appendix D: DGS Green Buildings Database

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Calilfornia Green Building Directory (www.greenbuildings.dgs.ca.gov); Appended to show just new construction projects. Updated October, 2008.

Bldg. Owner	Project/Building Name	City	Number of Buildings	Square Feet	Project Phase: October 2008	LEED Rating System	LEED Certification Level	LEED Status: October 2008	LEED Certification Date/FY	Retro-Commission	Project FY	RCx Phase: October 2008
DMV	Lincoln Park New/Replacement Field Office	Los Angeles	1	11,000	Acquisition	New Construction	Silver	Pursuing Certification	TBD	N/A		
DMV	Lodi New/Replacement Field Office	Lodi	1	8,000	Acquisition	New Construction	Silver	Pursuing Certification	TBD	N/A		
DMV	Thousand Palms Replacement Field Office	Thousand Palms	1	11,000	Acquisition	New Construction	Silver	Pursuing Certification	TBD	N/A		
CHP	New Area Office	Grass Valley	2	11,000	Study/Acquisition	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Las Posadas Forest Fire Station	Angwin	2	6,000	Study/Acquisition	New Construction	Silver	under 10K sq ft	not required	N/A		
CHP	Oceanside Area Office - Replacement	Oceanside	1	20,800	Study/Acquisition	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Hollister Air Attack Base Relocation	Hollister	7	14,100	Acquisition/Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DGS	Resources Agency Consolidation	Sacramento	2	1,400,000	Acquisition/Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DWR	New Science Center	Rio Vista	3	105,527	Acquisition/Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDE	Academic, Support, Bus Loop	Riverside	9	21,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Academy - Construct Dorm Bldg & Expand Mess Hall	Ione	2	20,322	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Alma Helitack Base	Los Gatos	3	11,066	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Bieber Forest Fire Station/Helitack Base	Bieber	6	25,000	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Growlersburg Conservation Camp	Georgetown	17	74,000	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Intermountain Conservation Camp	Bieber	5	29,300	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Ishi Conservation Camp	Paynes Creek	14	40,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Miramonte Conservation Camp	Miramonte	18	75,000	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Paso Robles Fire Station	Paso Robles	4	8,300	Preliminary Plans	New Construction	Silver	under 10K sq ft	not required	N/A		
CDF	Red Bluff Forest Fire Station/Unit Headquarters	Red Bluff	12	42,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Ukiah Air Attack Base - Relocate Facility	Ukiah	3	10,282	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CHP	New Area Office	Fresno	2	25,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CHP	New Area Office	Mojave	2	11,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CHP	Oakhurst Area Office - Replacement Facility	Coarsegold	1	9,558	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CHP	Santa Fe Springs Area Office, Replace Facility	Santa Fe Springs	1	23,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
CSC	CA African American Museum Renovation and Expansion	Los Angeles	1	105,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DGS	State Printing Facility (OSP)	Sacramento	1	250,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DMH	Napa State Hospital - Construct New Kitchen	Napa	1	29,000	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DMH	Patton State Hospital - Buildings H&J	Patton	3	61,974	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DMH	Patton State Hospital - Construct New Kitchen	Patton	1	29,000	Preliminary Plans	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DMV	New Driver Safety Office, Stockton	Stockton	1	10,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DMV	Field Office Reconfigure	Redding	1	7,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DMV	San Bernardino Field Office Reconfigure.	San Bernardino	1	10,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DMV	Stockton Field Office Reconfigure	Stockton	1	7,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DMV	Victorville Field Office Reconfigure	Victorville	1	9,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DOT	Philip Raine SRRA (Green Rest Stop)	Tipton	6	5,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
DVA	New Veterans Home	Redding	1	108,000	Preliminary Plans	Green Guide for Health Care	Silver	Pursuing Certification GGHC	TBD	N/A		
DVA	New Veterans Home	Fresno	1	216,000	Preliminary Plans	Green Guide for Health Care	Silver	Pursuing Certification GGHC	TBD	N/A		
DWR	Pear Blossom Admin. Building	Pear Blossom	1	15,000	Preliminary Plans	New Construction	Silver	Pursuing Certification	TBD	N/A		
SLC	Huntington Field Office	Huntington Beach	2	3,000	Preliminary Plans	New Construction	Silver	under 10K sq ft	not required	N/A		
CCC	Delta Service Center	San Joaquin Co.	4	29,581	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CCC	Tahoe Base Center Relocation	South Lake Tahoe	3	44,712	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDCR	Folsom SP - Convert Office & Guard Bldg to Office Space	Represa	1	20,000	Working Drawings	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDE	CTEC CA School for the Deaf	Riverside	2	10,720	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDE	Gymnasium & Swimming Pool Renovation	Riverside	1	45,000	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Altaville Forest Fire Station	Altaville	3	6,479	Working Drawings	New Construction	Silver	under 10K sq ft	not required	N/A		
CDF	Baseline Conservation Camp - Remodel Facility	Jamestown	5	12,412	Working Drawings	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Batterson Forest Fire Station - Relocate Facility	Madera Co.	2	4,051	Working Drawings	New Construction	Silver	under 10K sq ft	not required	N/A		

Calilfornia Green Building Directory (www.greenbuildings.dgs.ca.gov); Appended to show just new construction projects. Updated October, 2008.

Bldg. Owner	Project/Building Name	City	Number of Buildings	Square Feet	Project Phase: October 2008	LEED Rating System	LEED Certification Level	LEED Status: October 2008	LEED Certification Date/FY	Retro-Commission	Project FY	RCx Phase: October 2008
CDF	Bautista Conservation Camp - Remodel Facility	Hemet	7	15,540	Working Drawings	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Colfax Forest Fire Station - Replace Facility	Colfax	2	4,831	Working Drawings	New Construction	Silver	under 10K sq ft	not required	N/A		
CDF	Fenner Canyon Conservation Camp Const Admin Bldg	Valyermo	3	11,000	Working Drawings	New Construction	Silver	Pursuing Certification	TBD	N/A		
CDF	Nevada City Forest Fire Station	Nevada City	4	16,000	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	South Operations Headquarters - Relocate Facility	Riverside	6	43,700	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Warner Springs Forest Fire Station - Replace Facility	Warner Springs	2	4,830	Working Drawings	New Construction	Silver	under 10K sq ft	not required	N/A		
CDPH	BSL 3 Suite Lab Remodel	Richmond	1	2,000	Working Drawings	New Construction	Silver	under 10K sq ft	not required	N/A		
CHP	San Diego Area Office, Building Alterations	San Diego	1	11,800	Working Drawings	New Construction	Silver	Pursuing Certification	TBD	N/A		
DDS	Porterville Developmental Center, New Main Kitchen	Porterville	1	29,000	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DGS	Library/Courts Building	Sacramento	1	185,940	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	Retro-Commission	2011/2012	Scheduled
DMV	Headquarters 6th Floor Renovation & Central Plant	Sacramento	1	75,000	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DMV	New Field Office	Moreno Valley	1	15,216	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DMV	New Field Office	Tracy	1	9,972	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DOT	Inland Empire TMC	Fontana	1	45,144	Working Drawings	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CCC	Camarillo - Satellite Relocation	Camarillo	4	22,477	Construction	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDE	Central Plant CSDR	Riverside	1	5,000	Construction	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDE	Dormitories, CA School for the Deaf	Riverside	14	112,530	Construction	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
CDF	Boonville Forest Fire Station - Replace Facility	Boonville	4	9,628	Construction	New Construction	Silver	under 10K sq ft	not required	N/A		
CDF	Cloverdale Forest Fire Station - Replace Facility	Cloverdale	2	5,752	Construction	New Construction	Silver	under 10K sq ft	not required	N/A		
DGS	Central Plant	Sacramento	1	500,000	Construction	New Construction	Gold	Registered/Pursuing Certification	TBD	N/A		
DGS	District 3 Office Building Replacement	Marysville	2	230,000	Construction	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DGS	Office Building	Sacramento	1	303,390	Construction	New Construction	Silver	Registered/Pursuing Certification	2008/2009	Retro-Commission	2009/2010	Scheduled
DGS	Office Building	Sacramento	1	303,520	Construction	New Construction	Silver	Registered/Pursuing Certification	2009/2010	Retro-Commission	2009/2010	Scheduled
DGS	LA Crime Lab	Los Angeles	1	209,080	Construction	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DMH	Metropolitan State Hospital Central Kitchen & Satellites	Norwalk	1	27,200	Construction	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DMV	Hollywood Field Office, Lease	Hollywood	1	10,000	Construction	New Construction	Silver	Pursuing Certification	TBD	N/A		
DVA	Member Services Building	Yountville	1	70,000	Construction	New Construction	Silver	Registered/Pursuing Certification	TBD	N/A		
DVA	New Veterans Home	Lancaster	1	47,000	Construction	Green Guide for Health Care		Pursuing Green Guide for Health Care	TBD	N/A		
DVA	New Veterans Home	San Buenaventura	1	47,000	Construction	Green Guide for Health Care		Pursuing Green Guide for Health Care	TBD	N/A		
DVA	New Veterans Home	Los Angeles	2	379,000	Construction	Green Guide for Health Care		Pursuing Green Guide for Health Care	TBD	N/A		
STRS	Headquarters	West Sacramento	1	400,000	Construction	New Construction	Gold	Pursuing Certification	TBD	N/A		
		Total Buildings:	234									
	SF of projects in "Construction" and "Working Drawings":			**3,324,505**								
	SF of all projects:			**6,201,734**								

Integrating Building Commissioning into State Building Construction

Attachment I: The Cost-Effectiveness of Commercial-Buildings Commissioning

CONSULTANT REPORT

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Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
December 2008

Arnold Schwarzenegger, *Governor*

Subtask 3.0 Deliverable

CALIFORNIA ENERGY COMMISSION

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THE COST-EFFECTIVENESS OF COMMERCIAL-BUILDINGS COMMISSIONING

A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States

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An electronic version of this document and data input forms are available at
http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html

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Table 7. Results summary with quartile analysis: Existing buildings.

	Units	Number of projects	Min	Bottom 25%	Median	Average	Top 25%	Max
Commissioned floor area	ft^2	106	5,690	95,101	**151,000**	209,729	271,650	1,014,133
Commissioning Costs								
Total	$2003/building	102	3,214	26,112	**33,696**	46,442	45,862	476,554
Normalized - excluding non-energy impacts, NEIs*	$2003/$ft^2$	102	0.03	0.13	**0.27**	0.41	0.45	3.86
Normalized - only for cases including non-energy impacts, NEIs*	$2003/$ft^2$	11	-0.27	0.04	**0.17**	0.41	0.45	1.88
Cx agent fee as percentage of total commissioning fee	%	9	32%	35%	**67%**	57%	71%	76%
Costs paid by:								
Building owner	%	31	0%	32%	**50%**	47%	50%	100%
Utility (e.g. as rebate)	%	48	20%	50%	**84%**	75%	100%	100%
Other (e.g. research grant)	%	7	33%	100%	**100%**	90%	100%	100%
Utility rebates (included in above costs)	$2003/building	48	917	11,932	**20,500**	23,685	25,000	76,725
as % of total costs	%	48	20%	50%	**84%**	75%	100%	100%
Deficiencies								
Per building	Number/building	85	0.7	5.0	**11**	32	21.0	640.0
Per 100kft2	Number/100kft^2	85	0.1	2.8	**6**	24	18.3	225.6
Measures								
Per building	Number/building	75	1.0	4.5	**9.0**	20.3	18.0	481.0
Per 100kft2	Number/100kft^2	66	0.1	2.5	**5.9**	8.6	12.7	218.6
Total Energy Cost Saving								
Raw data (mixed energy prices and years)	nominal $/building-yr	100	-25,752	11,739	**33,629**	66,489	75,940	879,101
Local energy prices	$2003/building-yr	100	-26,595	13,351	**37,376**	75,393	80,615	1,034,667
Standardized US-average energy prices	$2003/building-yr	57	-39,043	14,646	**44,629**	105,156	98,708	1,776,371
Percent energy bill savings	%	74	-3%	7%	**15%**	18%	28%	54%
Normalized Energy Cost Savings								
Raw data (mixed energy prices and years)	nominal $/$ft^2$-yr	100	-0.09	0.11	**0.24**	0.42	0.46	3.83
Local energy prices	$2003/$ft^2$-yr	100	-0.09	0.11	**0.27**	0.47	0.52	4.33
Standardized US-average energy price	$2003/$ft^2$-yr	56	-0.13	0.11	**0.26**	0.54	0.72	3.23
Monetized non-energy impacts (one-time)								
Per project	$2003/project (1000s)	10	-281	-31	**-17**	-45	-11	-1
Normalized by floor area	$2003/ft2-yr	10	-0.55	-0.45	**-0.18**	-0.26	-0.10	0.00
Energy Savings								
Electricity	kWh/ft^2-yr	57	-0.70	0.64	**1.7**	2.2	2.76	9.72
Percent savings	%	46	-5%	5%	**9%**	11%	15%	36%
Peak electrical power**	W/ft^2	6	0.1	0.4	**0.6**	0.7	0.8	1.6
Percent savings	%	3	1%	2%	**2%**	7%	9%	17%
Fuel	kBTU/ft^2-yr	29	-14.2	2.3	**6.5**	16.6	13.5	209.5
Percent savings	%	19	-16%	1%	**6%**	13%	23%	67%
Thermal (chilled water, hot water, steam)	kBTU/ft^2-yr	19	6	32	**64**	94	122	356
Percent savings	%	16	13%	23%	**36%**	37%	48%	63%
Total	kBTU/ft^2-yr	57	-15	7	**17.0**	49.3	56	357
Percent savings	%	46	-7%	7%	**15%**	19%	29%	57%
Payback Times [undiscounted]								
Raw data (mixed energy prices and years)	years	99	-1.5	0.4	**1.0**	2.1	2.0	20.7
Local energy prices and inflation-corrected cx costs	years	99	-1.5	0.3	**1.0**	2.1	2.4	26.1
Standardized U.S. energy prices and inflation-corrected cx costs	years	59	-1.0	0.2	**0.7**	1.7	2.1	10.4

* Non-energy impacts (NEIs) include increases or decreases in first or operating costs due to changes in maintenance costs, contractor callbacks, equipment life, and
** Most are averaged over the entire year, hence true "peak" savings are significantly higher than shown here.

Table 8. Results summary with quartile analysis: New construction.

		Number of projects	Min	Bottom 25%	Median	Average	Top 25%	Max
Commissioned floor area	ft^2	69	1,072	32,268	65,500	118,369	151,000	685,000
Commissioning Costs								
Total	$2003/building	69	2,089	19,515	74,267	165,139	218,960	1,126,000
Normalized - excluding non-energy impacts, NEIs*	$2003/$ft^2$	69	0.10	0.49	1.00	1.64	1.66	18.20
Normalized - only for cases including non-energy impacts, NEIs*	$2003/$ft^2$	22	-7.82	-0.27	0.35	0.11	1.22	4.40
As % of construction cost (excl. NEIs) [%]*	%	65	0.1%	0.3%	0.6%	0.9%	1.1%	5.9%
As % of construction cost (incl. NEIs) [%]*	%	22	-5.2%	-0.2%	0.2%	0.03%	0.8%	1.5%
Cx agent fee as percentage of total commissioning fee	%	25	56%	74%	80%	78%	86%	94%
Costs paid by:								
Building owner	%	23	50%	50%	50%	72%	100%	100%
Utility (e.g. as rebate)	%	31	50%	50%	100%	79%	100%	100%
Other (e.g. research grant)	%	2	-	-	-	-	-	-
Utility rebates (included in above costs)	$2003/building	31	2,089	6,542	16,650	27,055	42,677	128,265
as % of total costs	%	31	50%	50%	100%	79%	100%	100%
Deficiencies								
Per building	Number/building	34	2	4	28	67	75	705
Per 100kft2	Number/100kft^2	34	5	16	37	90	81	1,010
Measures								
Per building	Number/building	21	2	3	7	55	30	705
Per 100kft2	Number/100kft^2	22	5	13	20	13	43	285
Total Energy Cost Saving								
Raw data (mixed energy prices and years)	nominal $/building-yr	33	39	362	1,944	22,604	14,628	300,000
Local energy prices	$2003/building-yr	33	46	369	2,288	24,785	14,937	306,344
Standardized US-average energy prices	$2003/building-yr	27	-68	622	2,533	9,226	13,722	61,288
Percent energy bill savings	%	-	-	-	-	-	-	-
Normalized Energy Cost Savings								
Raw data (mixed energy prices and years)	nominal $/$ft^2$-yr	33	0.00	0.02	0.05	0.25	0.13	3.20
Local energy prices	$2003/$ft^2$-yr	33	0.00	0.02	0.05	0.29	0.16	3.84
Standardized US-average energy price	$2003/$ft^2$-yr	30	0.00	0.02	0.05	0.11	0.19	0.44
Monetized non-energy impacts								
Per project	$2003/project (1000s)	22	-1418	-138	-51	-177	-15	17
Normalized by floor area	$2003/ft2-yr	22	-43.93	-6.96	-1.24	-6.11	-0.23	0.43
Energy Savings								
Electricity	kWh/ft^2-yr	29	-0.49	0.20	0.5	1.2	1.36	5.63
Percent savings	%	3	8%	8%	8%	10%	11%	13%
Peak electrical power**	W/ft^2	11	0.0	0.03	0.1	0.2	0.2	0.6
Percent savings	%	-	-	-	-	-	-	-
Fuel	kBTU/ft^2-yr	18	-3.6	0.2	2.2	2.1	3.4	13.5
Percent savings	%	-	-	-	-	-	-	-
Thermal (chilled water, hot water, steam)	kBTU/ft^2-yr	-	-	-	-	-	-	-
Percent savings	%	-	-	-	-	-	-	-
Total	kBTU/ft^2-yr	30	-1	2	3.2	6.2	8	26
Percent savings	%	-	-	-	-	-	-	-
Payback Times [undiscounted]								
Raw data (mixed energy prices and years)	years	39	0.0	1.9	6.5	23.0	19.5	303.1
Local energy prices and inflation-corrected cx costs	years	38	0.0	1.9	5.6	21.9	22.6	175.4
Standardized U.S. energy prices and inflation-corrected cx costs	years	39	0.0	1.2	4.8	14.0	16.6	105.0

* Non-energy impacts (NEIs) include increases or decreases in first or operating costs due to changes in maintenance costs, contractor callbacks, equipment life, and
** Most are averaged over the entire year, hence true "peak" savings are significantly higher than shown here.

Appendix C:
Task 5 Report - Pilot the Commissioning Services Implementation Plan Within a New State Building Project

Integrating Building Commissioning into State Building Construction

Appendix C: Task 5 Report - Pilot the Commissioning Services Implementation Plan Within a New State Building Project

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
August 2009

Arnold Schwarzenegger, *Governor*

CALIFORNIA ENERGY COMMISSION

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Integrating Building Commissioning into State Building Construction

Arnold Schwarzenegger
Governor

Task 5: Draft Commissioning Report for Cal Trans Building

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

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Architectural Energy Corporation

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DISCLAIMER

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Draft Commissioning Report for Cal Trans Building is an interim report prepared by Architectural Energy Corporation under the Integrating Building Commissioning into State Building Construction Program (contract number 500-04-016) that is managed by Architectural Energy Corporation. The information from this project contributes to PIER's Buildings End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research or contact the Energy Commission at 916-654-5164.

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Attachment I: Report

Abstract

The goal of the Integrating Building Commissioning into State Building Construction program is to improve the realization and persistence of proper operation and resource efficiency in new State buildings or major renovations, resulting in lower energy use, lower operation and maintenance costs to the State, longer building life, as well as greater worker productivity and user comfort.

1.0 Executive Summary

The goal of this task is to demonstrate the process of implementing commissioning services in an actual State building construction project.

The project team provided a person to be the commissioning authority to work with Department of General Services staff in commissioning the Cal Trans District 3 office complex in Marysville, California. The commissioning process began during the pre-design activities and extended through design, construction, and nearly the first year of occupancy.

The execution and outcomes of this task have provided information needed to complete Task 6 – Revise and Present the Commissioning Services Plan and Task 7 – Communicate Results to State Agencies and to the General Public.

The completed Draft Commissioning Report, as prepared by the commissioning authority, is included with this report as Attachment I. This is done out of practicality as the report includes project team correspondence, company-specific forms, and software-generated lists that are not easily incorporated into the California Energy Commission reporting format. The Draft Commissioning Report is excerpted as possible for this report, with reference to Attachment I as needed.

2.0 Introduction

2.1. Background

This new building consists of a 220,832 sq. ft. five-story building on 820 Chestnut Street in Marysville, California for Caltrans. The project has been conceived for Caltrans to fit within the community, using a truly collaborative approach; an integral design, engineering and construction solution that combines architecture, structure, interiors and building systems. The facility will accommodate various office, meeting, and presentation areas with a day-lit atrium. This report summarizes the commissioning activities performed at Architectural Energy Corporation San Francisco Office. The report is a compilation of the project's commissioning history, with valuable information to help future facility operators understand the decision making process that occurred during the design and construction of this project, and to help in future maintenance operations.

2.2. Building Description

Caltrans District 3 Office Building Replacement is a 220,832 sq. ft. office building. It is served by a HVAC system comprised of five roof top AC units, packaged cooling units for each zone, make-up air units, CRAC units, dry coolers, cooling towers, boilers, heat exchangers, and exhaust fans. The building operates on a schedule and is controlled and adjusted from the Siemens BAS system.

Multiple levels of lighting control will be available in nearly all areas with the exception of electrical and mechanical rooms. Duel leveled and zoned controls in addition to the photo control sensors will streamline the energy usage with override control available. Lobby areas will be based on an integrated astronomical time clock.

The following building systems were commissioned by AEC:

- Roof top AC units with water cooling
- Make air unit
- CRAC units
- Packaged cooling units
- Dry cooler
- Boilers
- Cooling towers
- Heat exchanger
- Exhaust fans
- Electric and gas water heater
- Lighting controls and daylight dimming controls

2.3. Commissioning Methodology

As practiced by AEC, building commissioning is a comprehensive and systematic process to verify that the systems of a new building perform as designed to meet the owner's requirements. The AEC approach to commissioning is to form a cooperative commissioning team involving the owner, design team, and general contractor and appropriate sub-contractors to design and deliver effective, efficient, high performance buildings. Commissioning by AEC is a structured process to verify and document that applicable building systems meet the design intent and owner's operational requirements.

The commissioning agent is involved in design reviews, construction documents review, design intent and basis of design documentation, and a variety of functional testing tasks and performance verification. A common objective of all these activities is to identify and resolve operational and performance issues at the earliest possible time, because to do so saves time and money.

Design and construction document reviews identify and resolve construction, operation, and maintenance issues before they can become physical mechanical problems. Construction observation and pre-functional inspection checklists formalize the start-up process, ensuring that equipment or systems are ready for acceptance testing. Functional performance testing becomes a management tool for the owner to fully understand the "completion stage" of a facility construction process, and associated acceptance and payment procedures.

As a formal process, commissioning identifies and resolves operational and performance problems during the construction, start-up, and acceptance phases which reduces warranty call-backs. The occupants and operations staff receive a fully functioning facility to move into. Another important benefit of a formal commissioning process is the active participation of the buildings operation and maintenance (O&M) staff in the commissioning process. The O&M staff's participation in the commissioning activities supports their efforts to operate and maintain the commissioned systems at peak performance.

From our experience, commissioning enables the design and construction processes to run smoothly. It is a win-win situation for owners, occupants, design team, contracting team, and O&M staff. The building has been "checked out" and is ready for occupancy, knowing that commissioned equipment and systems perform as designed. To provide for optimal performance longevity, the AEC commissioning report (2 copies) to the owner and tenant includes detailed information about the equipment design parameters, operation, deficiency history and preventative maintenance requirements.

The AEC commissioning team performed the following activities to achieve the project objectives:

1) Prepared a commissioning plan
2) Performed design and submittal reviews
3) Organized commissioning scoping meetings
4) Reviewed completed pre-functional inspection checklists
5) Performed jobsite inspections
6) Completed functional performance testing
7) Prepared and updated issues logs
8) Prepared the commissioning report

Scope of Work for this project covers the following LEED credit:

- EA Prerequisite 1 – Fundamental Commissioning
- EA Credit 3 – Enhanced Commissioning

Scope of Commissioning Services covers the following systems and components:

- HVAC components such as;
    - Roof top AC units with water cooling
    - Make air unit and heat exchanger
    - Exhaust fans and CRAC units
    - Dry cooler and cooling towers
    - Electric and gas water heater
    - Packaged cooling units
    - Boilers and pumps
    - Controls
- Lighting System
    - Compliance w/ Building Occupancy
    - Occupancy Controls
    - Day lighting controls

2.4. Commissioning Summary

Below is a brief summary of the mechanical HVAC design and equipment, as well as the lighting and day lighting control scheme.

Mechanical Systems

The HVAC system is consisted of five custom rooftop packaged air-conditioning units with water cooling, packaged cooling units, back up dry coolers, cooling towers, and boilers. There are also CRAC units, a heat exchanger, exhaust fans, and water heaters. All HVAC systems are controlled based on building schedule adjusted by controllers in central control room.

Lighting Systems

Duel level occupancy sensors and integrated photo daylight sensors are designed in work areas and support spaces to control the electric lighting. A "manual ON and OFF" and "auto OFF" strategy will be used for the control devices. All employees shall have access to lighting controls.

Identification and Resolution of Deficiencies

The inspections and testing procedures identified several deficiencies. Included in the Issues Log Section is a complete issues log. Each issue on this list includes the adjustments or alterations required to correct the system operation, the party responsible for making the adjustments, as well as the dates of identification and resolution. Most issues were resolved by the responsible sub-contractors through installation and programming changes during the testing and punch list period.

2.4.1. Commissioning Finding and Notes

This section discusses several issues related to commissioning and resolving deficiencies. Deficiencies we discovered during site visits on November 20, 21 and 25 are listed below:

Liebert CRAC-1, 2 and 3 were controlled by Liebert's high level interface. Only operation status and parameters were provided to Siemens BAS. Due to this limitation, MC and CC shall demonstrate to the operating staff that continuous CRAC operation is maintained whenever the CW supply is switched over from CTs to Drycoolers and from Drycoolers back to CTs.

The graphical user interface of the Siemens BAS was verified not completed. Siemens indicated that graphical screens for VAVs, PCUs, EFs and miscellaneous equipment would be uploaded by December.

Petra building static pressure sensors, for the AC-1 through 5 units, read positive values instead of negative values measured on the 1/F right next to the sensing probes. It appeared that the RFs were running at minimum speed but the OA intake CFM was still less than CFM discharged from the relief damper for Petra units. MC and CC would re-calibrate of all static pressure sensor of Petra units. After the adjustment, they shall also demonstrate to the operating staff that the Petra fan speed controls are able to maintain design building static pressure in various supply air demand from terminal devices.

The CRAC-1, 2 and 3 units were tripped due to high compressor pressure alarms due to loss of CW flow. MC and CC should verified that both DC CW control valves (DCV-1 & 2) modulate proportionally to ensure continuous CW circulation thru the condensers of the CRAC units.

Please refer to the Issues Log section in Attachment I (Section 6) for the complete list of noted deficiencies.

3.0 Owner's Project Requirements (OPR) & Basis of Design (BOD)

The Owner's Project Requirements (OPR) documents functional requirements and the criteria the owner will use to determine whether these requirements have been fulfilled. Developing the OPR requires these groups to reach consensus on, or at least accept, common functional requirements. For owners that are new to construction, developing an OPR may facilitate awareness of critical performance issues early on, when they can be addressed by the basis of design. This minimizes the potential for becoming aware of these issues after occupancy. The value of the OPR is increased by not only describing the owner's functional requirements, but also clarifying how the successful fulfillment of these requirements will be judged. In many cases, the very nature of these requirements may adequately communicate the success criteria. An effective OPR is a living document. As functional performance questions arise during design, the team looks to the OPR for the answer. If the answer is not in the document, a revision may be warranted to address the subject.

The Basis of Design (BOD) documents the concepts on which systems are based, the methodology used to approach the design, and how the design satisfies the OPR. The BOD may be thought of as the design team's confirmation of the OPR. While the OPR describes the owner's functional requirements, the BOD is the design team's opportunity to confirm that they understand the requirements and describe how they intend to achieve them with the design. For this reason, there is value in involving the design team in the development of the OPR. The BOD records concepts, design assumptions, important calculations, decisions, product selections, rationale, and other applicable regulations, standards, and guidelines the design incorporates to satisfy the OPR. It is possible to use the actual electronic OPR file to develop a BOD checklist, or even as an effective starting point for BOD document itself. These approaches automatically direct the design team to every item in the OPR. As the BOD takes form, the format may include narrative text, schematic zoning plans, one-line schematic systems diagrams, and data tables.

LEED for New Construction Version 2.2 requires the following regarding the OPR and BOD: "The owner shall document the OPR. The design team shall develop the BOD. The CxA shall review these documents for clarity and completeness. The owner and design team shall be responsible for updates to their respective documents."

It is critical to maintain an open dialog between the owner and the design team in order for the design process to proceed smoothly resulting in a project meeting owner's expectations with respect to form and function.

Please refer to Attachment I (Section 2) to review complete Building Owner's Requirements and Basis of Design materials.

4.0 Commissioning Plan

The Commissioning (Cx) Plan is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Cx Process. The Cx plan was presented to the commissioning team early in the construction process, and all parties involved agreed to uphold it as written. A well-written Cx plan results in a quality-focused process that contribute to a more effective and complete project. Cx activities focus on verification of proper design and construction of facility systems and assemblies to meet the Owner's Project Requirements.

A copy of the commissioning plan appears in Attachment I (Section 3).

5.0 Design Reviews & Submittal Reviews

Design and submittal review were written by AEC staff in compliance with LEED Enhanced commissioning requirements; all correspondence and review materials appear in Attachment I (Section 4). The Design/Construction Team responses to reviews issued by CxA are also included in Section 4 of Attachment I.

HVAC system review should include:

- Review of site design conditions for potential impact on system performance (e.g., are systems suitable for climactic conditions at that site, as defined by ASHRAE)
- Major IAQ issues including: temperature/humidity control, filtration, ventilation control.
- HVAC and envelope interactions pressure relationships (e.g., are depressurized areas of the building located adjacent to exterior walls where infiltration may cause problems)
- Clarity of the control sequences of operation, including emergency responses
- Controls submittal requirements and clarity of control responsibility between equipment manufacturer and central system controls
- Ability of the system to be commissioned
- Sufficient points and features in the control system
- Adequate space for installation, testing, operation and maintenance access
- Equipment redundancy requirements, if necessary
- Reality check of system sizing

Electrical System review should include:

- Lighting controls – functionality and energy efficiency
- Daylight dimming control systems are clearly shown and specified

6.0 Memos, Meeting Notes, and Relevant Correspondence

This section contains selected documents produced during the course of commissioning by members of the commissioning team. They are included in Attachment I (Section 5) to highlight important issues encountered during the commissioning process, as well as to illustrate a resolution path taken by the commissioning team.

7.0 Issues Log

Issues logs provide a summary of items found during the commissioning process, specifically during functional performance tests. Issues Log may be in a form of a Table or a memo depending on the number of issues discovered and tracked. A table includes a reference number, the equipment name and location, a code for how the issue was identified, a description of the issue, a cause code, the date identified, action to be taken, date resolved, a responsibility code, and a comment field.

Attachment I (Section 6) includes an issues log for work performed on the Cal Trans District 3 office complex in Marysville, California.

8.0 Sequences of Operation

This section describes sequences of operation for mechanical/HVAC installed at this project. Sequence of Operation determines the ability of the facility to perform in an energy-efficient manner. The importance of describing the function of the mechanical systems undergoing commissioning with detailed, comprehensive control strategies cannot be overemphasized.

Topics that affect energy efficiency and should be addressed by the sequence of operation control strategies include:

- systems and equipment controlled
- system initiation
- modes of operation
- cooling heating & ventilation
- occupied periods & unoccupied periods
- set points for temperature, pressure, humidity
- set-back routines

- optimal starts
- time limited control of equipment
- override sequences
- alarm point ranges
- control vs. monitoring point descriptions

Attachment I (Section 7) contains a detailed sequences of operation report.

9.0 Pre-Functional Checklists

Pre-functional Checklists (PFCs) are an essential part of the installation and inspection process. The Commissioning Authority (CxA) needs to confirm that the contractor-supplied forms contain information sufficient to verify correct equipment installation. PFCs must be filled out by the respective trade contractor. They are then collected and submitted to the CxA by the General Contractor. The CxA reviews completed PFCs and if deficiencies are discovered, they must be resolved prior to scheduling Functional Performance Tests (FPTs), which follow.

Pre-functional Checklists are commonly created by the CxA, but in this project those forms were prepared by the contractors. This had been agreed to by the owner's representative and the CxA.

Attachment I (Section 8) contains a detailed listing of PFTs.

10.0 Functional Performance Test Plan and Results

This section contains completed FPT forms used to test mechanical, electrical, lighting & control systems at the facility. The FPTs in this section were created based on sequences of operation and were used to verify intended operation of the systems mentioned below. The contractor(s) and Commissioning Agent (CxA) performed the hardware and/or software manipulations required to perform the tests. Test procedures were witnessed and observations recorded by the CxA and other commissioning team members.

The benefits usually associated with Functional Performance Testing include energy and resource savings, greater reliability of installed equipment, as well as improved indoor air quality.

At the time of preparation, the draft commissioning report contained in Attachment I is incomplete. Only some functional performance tests had been completed due to system operation issues, as noted in correspondence included in Attachment I (Section 9). It was agreed that BPM and operation & maintenance personnel will continue with the functional performance testing after all major issues have been resolved. The CxA will provide necessary assistance to BPM in facilitating the process.

11.0 Field Commissioning Documentation

This section includes blank functional performance tests (FPTs) forms developed for commissioning of HVAC, DHW, and lighting control systems. FPTs provide functional performance testing procedures; methods to simulate various operation conditions, expected observations and results; and the remark column to note additional observations and comments.

Final version of the Sequence of Operation of the corresponding system to be commissioned is also included in the introduction section of the FPTs forms as a hands-on reference for testing personnel.

Attachment I (Section 10) includes blank FPTs forms.

12.0 LEED™ Compliance Forms

Requirements for following Leadership in Energy and Environmental Design (LEED®) Certification online template registration will be completed by the AEC engineering staff.

Attachment I (Section 11) includes the forms as completed to date pending final FPTs and field commissioning documentation.

13.0 Conclusion

The overall goal of this Public Interest Energy Research PIER project was to demonstrate and initiate an in-house, framework and process for implementing commissioning (Cx) services in an actual State building construction project utilizing various branches, sections, and personnel within the Real Estate Services Division (RESD) in the State's Department of General Services (DGS). The most challenging part of this process was to coordinate commissioning-related activities between several different stake holders in this project.

Some of the issues encountered during different phases are listed below. The pilot program for developing and initiating an in-house Cx capability, Task 5 of the overall PIER project, entailed commissioning the Caltrans District 3 building in Marysville, California. The lessons learned during this task served to guide the development of the in-house Cx framework, to validate the cost-benefit of commissioning, and to forge a better coordination between various DGS branches and sections.

This report and the Task 3 report detail issues, difficulties, and lessons learned in developing and refining an effective in-house Cx framework. A clear finding from the Task 5 efforts is the need to forge a stronger, integrated relationship between DGS's Project Management Branch (PMB) and the Building and Property Management Branch (BPM), and to integrate the Design Services Section (DSS) and Construction Services Section (CSS) - which reside within the

Professional Services Branch (PSB) - into the in-house framework. The PMB project director (PD), who has authority over a project, including the Cx process, is most effective if his or her role is better structured within a team framework as elaborated in the Task 6 report. Critically, BPM needs to be fully recognized and accepted as a stakeholder in capital outlay projects from the inception. This became abundantly clear during the Task 5 efforts.

Additional Task 5 findings are summarized as follows for each building phase:

Phase I - Planning

The first phase of any commissioning project needs to be the development of a plan that could be implemented. Successful execution of any plan depends on the selection of Cx team members and a clear definition of the project objectives. The Cx Team shall be composed of people familiar with and supportive of the commissioning process. The Task 6 report outlines the stakeholders in an effective Cx team and a framework for implementation. It is important to initiate this process during the first meeting to clearly define the goals that the Team is setting and determine the process in attaining them. Some of the areas where difficulties were experienced include:

- Defining & Cx Team Roles and Responsibilities
- Work & Communication Protocols
- Agreeing on documentation requirements
- Deadlines & scheduling

Phase II - Construction

The goal of this phase was to follow installation of the building system in accordance with the system design intent. The design intent) describes the operation of building systems as intended by the Design Engineer. Pre-functional checklists and startup procedures are used to verify proper installation and initial operation of the equipment. Properly written sequences of operation are a critical part of this phase. Sequence narratives are often provided as part of the original design documents but must be reviewed by the design engineer and controls contractor prior to their implementation. Areas where difficulties were experienced include:

- Collection of the completed and signed pre-functional checklists (PFCs)
- Thorough reviews of functional performance tests (FPTs) by contractors
- Deadlines & scheduling

Phase III – Comprehensive Functional Testing

Once all PFCs are collected and verified as complete, it then becomes time to complete a comprehensive functional testing of all system components. The Cx Team schedules functional performance testing based on documented functional testing routines discussed with contractors and designed to verify the correct operation of the system through all potential modes of operation. In the case of the HVAC system, tests cover various modes of operation such as warm-up mode, economizer mode, mechanical cooling mode, and mechanical heating

mode. All issues identified during these tests are documented and tracked until resolved. Areas where difficulties were experienced include:

- Equipment installation schedule problems (not ready for testing)
- Scheduling test events
- Gaps in sequences of operations not discovered during 'Review Stage'
- BAS system limitations in regard to control of air handling units not defined earlier
- Assistance from construction crew and building service personnel with testing activities

This last issue was remedied toward the end of the project and the commissioning team received the level of cooperation required to successfully proceed with testing and complete the commissioning process. Coordination issues were plentiful at this phase and the preceding one, reinforcing the need for a stronger, team-based Cx framework that better empowers the PD and incorporates the team support provided by BPM and various PSB personnel.

Phase IV – Issue Resolution

The functional testing phase almost always results in discovery of a number of issues that remain unresolved. However, as discussed in the Task 6 report, implementation of better upstream quality in the early planning and design phases can minimize issues discovered at the functional testing phase. For the issues discovered at functional testing, it is critical for the Cx Team to meet and reach consensus on who will be responsible for fixing those issues. Additional meetings may be scheduled to review progress and at some point the Cx Team will reach an agreement that the process has been completed to the Owner's satisfaction and that the systems are now functioning in compliance with the design intent. The commissioning authority (CxA) team then would typically package all the documentation generated in the form of review reports, test reports, and the final version of the issues log. This documentation would be presented to the Owner and the entire Cx team as the Final Commissioning Project Report. Areas where difficulties were experienced include:

- Many tests could not be completed. Too many problems with systems/device readiness
- Slow contractor response to issues raised during testing phase
- Verification of all issue resolution to the satisfaction of the Cx team

Of concern is that occupancy of the building was initiated prior to all issues being resolved. A better structured, team-based Cx framework and better coordination between the PD (from PMB) and the Building Manager and Chief Engineer (from BPM) could preclude such difficulties if the proposed Cx framework is implemented and BPM as a whole positively embraces BPM as a stakeholder and viable team member in the Cx process.

Conclusion

The hardest part of this process was initiating it, but once it commenced and the parties actively participating, their commitment to commissioning activities grew as test results began to reveal problems. All Cx team participants - including DGS personnel, the contractor, and sub-contractors - have learned more about building systems and their interaction through the Cx

process than they have acquired through the many technical classes they may have attended. Also, there is a great deal of satisfaction in discovering the underlying reasons a particular building system or piece of equipment has problems and creating a means to fix or preclude those problems for proper system function.

Integrating Building Commissioning into State Building Construction

Attachment I: Draft Commissioning Report for Cal Trans Building

Permission for electronic publishing of these materials in Adobe Acrobat PDF format on the California Energy Commission's Web Site has been granted by Architectural Energy Corporation 17 July, 2009. It is understood that there will be no time limit on the permission so that materials as an attachment to a PIER Program report would live indefinitely on the Energy Commission's Web Site.

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Public Interest Energy Research Program

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Arnold Schwarzenegger, *Governor*

Subtask 5.0 Deliverable

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Caltrans District 3 Office Building Replacement, Marysville, California

Preliminary Commissioning Report

July, 2009

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Executive Summary

This report summarizes the commissioning activities performed by AEC on behalf of the California State Department of General Services at the facility located on 820 Chestnut Street, Marysville, CA. This commissioning effort covers the open office, multi-story, day-lit atrium environment under LEED-NC guidelines. The Owner has engaged AEC as a commissioning authority and tasked the commissioning agent with producing a commissioning report upon completion of commissioning activities.

AEC was in the process of verifying that the fundamental building elements for which LEED-NC credit is sought are designed, installed and calibrated to operate as intended for the tenant's scope of work. During this process a number of deficiencies was discovered. This report details Cx procedures used and lists deficiencies found. Our commissioning effort will be continued by BPM personnel who will carry out remaining Cx procedures and make sure that problems discovered in early stages of commissioning are resolved. When this is accomplished the Final Cx report will be submitted to USGBC to achieve LEED Gold Certified rating as originally planned.

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11.0 LEED™ COMPLIANCE FORMS

1.0 Project Summary

Background

This new building consists of a 220,832 sq. ft. five-story building on 820 Chestnut Street in Marysville, CA for Caltrans. The project has been conceived for Caltrans to fit within the community, using a truly collaborative approach; an integral design, engineering and construction solution that combines architecture, structure, interiors and building systems. The facility will accommodate various office, meeting, and presentation areas with a day-lit atrium. This report summarizes the commissioning activities performed at Architectural Energy Corporation San Francisco Office. The report is a compilation of the project's commissioning history, with valuable information to help future facility operators understand the decision making process that occurred during the design and construction of this project, and to help in future maintenance operations.

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- Lighting controls and daylight dimming controls

Commissioning Methodology

As practiced by AEC, building commissioning is a comprehensive and systematic process to verify that the systems of a new building perform as designed to meet the owner's requirements. The AEC approach to commissioning is to form a cooperative commissioning team involving the owner, design team, and general contractor and appropriate sub-contractors to design and deliver effective, efficient, high performance buildings. Commissioning by AEC is a structured process to verify and document that applicable building systems meet the design intent and owner's operational requirements.

The commissioning agent is involved in design reviews, construction documents review, design intent and basis of design documentation, and a variety of functional testing tasks and performance verification. A common objective of all these activities is to identify and resolve operational and performance issues at the earliest possible time, because to do so saves time and money.

Design and construction document reviews identify and resolve construction, operation, and maintenance issues before they can become physical mechanical problems. Construction observation and pre-functional inspection checklists formalize the start-up process, ensuring that equipment or systems are ready for acceptance testing. Functional performance testing becomes a management tool for the owner to fully understand the "completion stage" of a facility construction process, and associated acceptance and payment procedures.

As a formal process, commissioning identifies and resolves operational and performance problems during the construction, start-up, and acceptance phases which reduces warranty call-backs. The occupants and operations staff receive a fully functioning facility to move into. Another important benefit of a formal commissioning process is the active participation of the buildings operation and maintenance (O&M) staff in the commissioning process. The O&M staff's participation in the commissioning activities supports their efforts to operate and maintain the commissioned systems at peak performance.

From our experience, commissioning enables the design and construction processes to run smoothly. It is a win-win situation for owners, occupants, design team, contracting team, and O&M staff. The building has been "checked out" and is ready for occupancy, knowing that commissioned equipment and systems perform as designed. To provide for optimal performance longevity, the AEC commissioning report (2 copies) to the owner and tenant includes detailed information about the equipment design parameters, operation, deficiency history and preventative maintenance requirements.

The AEC commissioning team performed the following activities to achieve the project objectives:

1. Prepared a commissioning plan
2. Performed design and submittal reviews
3. Organized commissioning scoping meetings
4. Reviewed completed pre-functional inspection checklists
5. Performed jobsite inspections
6. Completed functional performance testing
7. Prepared and updated issues logs
8. Prepared the commissioning report

Scope of Work for this project covers the following LEED credit:

- EA Prerequisite 1 – Fundamental Commissioning
- EA Credit 3 – Enhanced Commissioning

Scope of Commissioning Services covers the following systems and components:

- HVAC components such as;
  - Roof top AC units with water cooling
  - Make air unit and heat exchanger
  - Exhaust fans and CRAC units
  - Dry cooler and cooling towers
  - Electric and gas water heater
  - Packaged cooling units
  - Boilers and pumps
  - Controls
- Lighting System
  - Compliance w/ Building Occupancy
  - Occupancy Controls
  - Day lighting controls

Commissioning Summary

Below is a brief summary of the mechanical HVAC design and equipment, as well as the lighting and day lighting control scheme.

Mechanical Systems

The HVAC system is consisted of five custom rooftop packaged air-conditioning units with water cooling, packaged cooling units, back up dry coolers, cooling towers, and boilers. There are also CRAC units, a heat exchanger, exhaust fans, and water heaters. All HVAC systems are controlled based on building schedule adjusted by controllers in central control room.

Lighting Systems

Duel level occupancy sensors and integrated photo daylight sensors are designed in work areas and support spaces to control the electric lighting. A “manual ON and OFF” and “auto OFF” strategy will be used for the control devices. All employees shall have access to lighting controls.

Identification and Resolution of Deficiencies

The inspections and testing procedures identified several deficiencies. Included in the Issues Log Section is a complete issues log. Each issue on this list includes the adjustments or alterations required to correct the system operation, the party responsible for making the adjustments, as well as the dates of identification and resolution. Most issues were resolved by the responsible sub-contractors through installation and programming changes during the testing and punch list period.

Commissioning Finding and Notes

This section discusses several issues related to commissioning and resolving deficiencies. Deficiencies we discovered during site visits on November 20, 21 and 25 are listed below:

1. Liebert CRAC-1, 2 and 3 were controlled by Liebert's high level interface. Only operation status and parameters were provided to Siemens BAS. Due to this limitation, MC and CC shall demonstrate to the operating staff that continuous CRAC operation is maintained whenever the CW supply is switched over from CTs to Drycoolers and from Drycoolers back to CTs.

2. The graphical user interface of the Siemens BAS was verified not completed. Siemens indicated that graphical screens for VAVs, PCUs, EFs and miscellaneous equipment would be uploaded by December.

3. Petra building static pressure sensors, for the AC-1 through 5 units, read positive values instead of negative values measured on the 1/F right next to the sensing probes. It appeared that the RFs were running at minimum speed but the OA intake CFM was still less than CFM discharged from the relief damper for Petra units. MC and CC would re-calibrate of all static pressure sensor of Petra units. After the adjustment, they shall also demonstrate to the operating staff that the Petra fan speed controls are able to maintain design building static pressure in various supply air demand from terminal devices.

4. The CRAC-1, 2 and 3 units were tripped due to high compressor pressure alarms due to loss of CW flow. MC and CC should verified that both DC CW control valves (DCV-1 & 2) modulate proportionally to ensure continuous CW circulation thru the condensers of the CRAC units.

Please refer to the Issues Log section for the rest of the deficiencies.

End of Section 1

2.0 Owner's Project Requirements (OPR) & Basis of Design (BOD)

The Owner's Project Requirements (OPR) documents functional requirements and the criteria the owner will use to determine whether these requirements have been fulfilled. Developing the OPR requires these groups to reach consensus on, or at least accept, common functional requirements. For owners that are new to construction, developing an OPR may facilitate awareness of critical performance issues early on, when they can be addressed by the basis of design. This minimizes the potential for becoming aware of these issues after occupancy. The value of the OPR is increased by not only describing the owner's functional requirements, but also clarifying how the successful fulfillment of these requirements will be judged. In many cases, the very nature of these requirements may adequately communicate the success criteria. An effective OPR is a living document. As functional performance questions arise during design, the team looks to the OPR for the answer. If the answer is not in the document, a revision may be warranted to address the subject.

The Basis of Design (BOD) documents the concepts on which systems are based, the methodology used to approach the design, and how the design satisfies the OPR. The BOD may be thought of as the design team's confirmation of the OPR. While the OPR describes the owner's functional requirements, the BOD is the design team's opportunity to confirm that they understand the requirements and describe how they intend to achieve them with the design. For this reason, there is value in involving the design team in the development of the OPR. The BOD records concepts, design assumptions, important calculations, decisions, product selections, rationale, and other applicable regulations, standards, and guidelines the design incorporates to satisfy the OPR. It is possible to use the actual electronic OPR file to develop a BOD checklist, or even as an effective starting point for BOD document itself. These approaches automatically direct the design team to every item in the OPR. As the BOD takes form, the format may include narrative text, schematic zoning plans, one-line schematic systems diagrams, and data tables.

LEED for New Construction Version 2.2 requires the following regarding the OPR and BOD: "The owner shall document the OPR. The design team shall develop the BOD. The CxA shall review these documents for clarity and completeness. The owner and design team shall be responsible for updates to their respective documents."

It is critical to maintain an open dialog between the owner and the design team in order for the design process to proceed smoothly resulting in a project meeting owner's expectations with respect to form and function.

Owner's Project Requirements

1. Owner and User Requirements

The new Caltrans District 3 Office Building Replacement project is located in Marysville, California. The building is normally occupied from 9:00 am to 5:00 pm Monday-Friday. Heating set point – 72^0F and Cooling set point of – 74^0F. Occupancy of the building includes ~776 employees assigned to different office areas. Each HVAC unit should serve one or more areas as shown on final set of CDs.

2. Environmental and Sustainability Goals

A. Project shall meet LEED® NC v2.2 requirements for LEED® Gold rating level.

3. Energy Efficiency Goals

A. Project shall comply with Title 24 building energy efficiency standards.

B. Lighting systems offer cost effective energy savings potential, and lighting fixtures and/or controls shall be selected to exceed Title 24 minimum efficiency requirements by 10% or greater.

C. High efficiency HVAC equipment offers cost effective energy savings, and HVAC equipment shall be selected that exceeds Title 24 minimum efficiency requirements by 10% or greater.

D. Additional energy efficiency measures that provide cost effective energy savings shall be included wherever feasible.

4. Indoor Environmental Quality Requirements

A. Indoor lighting and occupant lighting control requirements: Multiple levels of lighting control will be available. Duel leveled and zoned controls in addition to the photo control sensors will streamline the energy usage with override control available.

B. Thermal comfort requirements: Mechanical systems shall function seamlessly to deliver the performance levels needed to maintain space comfort within specifications set forth by ASHRAE Standard 55-2004. The HVAC system will be capable of providing outside air volume that exceed ASHRAE Standard 62.1-2004 and maintain adequate levels of building pressurization. Humidity levels in the space must always be maintained less than 60% relative humidity and should never be allowed to reach a level that would allow condensate to form on HVAC equipment or other building elements. Lighting controls in spaces with no occupancy sensors shall be "time-of-day" with temporary override that places HVAC and lighting systems into occupied mode. A Siemens BAS system shall provide a turnkey solution to machine-to-machine communications and shall be capable of remote access/alarm notification.

C. Ventilation and filtration requirements: Ventilation to be 30% greater than ASHRAE Standard 62.1-2004 minimums

D. Occupancy HVAC control requirements: The building operates on a schedule and is controlled and adjusted from the Siemens BAS controller. Building occupancy schedule for HVAC systems will be easily modified by zone.

5. Equipment and Systems Expectations

A. Special HVAC equipment requirements: Petra Roof Top AC Water Cooled AC Units. These are 125 tons units that provide a majority of cooling and heating for the building.

B. Special lighting equipment requirements: Lighting system should be based on tasks that will be performed in each space/area of the building. Lighting priority will be given to working areas which need greater light outputs. Duel leveled and zoned controls in addition to the occupancy control sensors will streamline the energy usage with override control available. External areas will be based on an integrated astronomical time clock.

6. Building Occupant and O&M Personnel Expectations

A. Day-to-day HVAC operation by: Maintenance Staff. The building needs to provide a necessary comfort to the occupants and clients year round. Excellent indoor environmental quality requirements that facilitate occupants' productivity by providing a comfortable environment while avoiding the design attributes related to poor HVAC system performance. The Owner desires to minimize undesirable environmental impacts and achieve LEED® Gold under LEED® NC v2.2 Rating System.

B. Periodic HVAC maintenance performed by: Maintenance Staff. All serviceable building equipment should easily accessible to maintenance staff. Outside vendor will perform maintenance of HVAC and lighting systems.

C. Training required for operating staff, maintenance staff, and building occupants: Training and Service Binders and Meetings.

Basis of Design

Caltrans District 3 Office Building Replacement
820 Chestnut Street, Marysville, CA

The Caltrans District 3 Office Building Replacement has been designed to achieve the LEED® Gold rating level of sustainability under the US Green Building Council's Leadership in Energy and Environmental Design green building rating system NC v2.2. These design rationales show how the project's design will help the owner meet their performance criteria.

Primary Design Assumptions

LEED
Primary Design Assumptions including – Space use, redundancy, diversity, climatic design conditions, space zoning, occupancy, operations and space environmental requirements.

Description of Assumption	Value (units)	
Climatic Design Conditions		
Elevation	63 ft.	
Latitude/Longitude	39.1°/121.6°	
Average Snowfall (Snow Melt Sys.)	0.00 in	
Clearness number		
Ground reference		
Outdoor Air	**Heating**	**Cooling**
Outside Air Dry Bulb Temperature	33°	90°
ASHRAE design %		
Outside Air Wet Bulb Temperature	31°	68°
ASHRAE design %		
Wind speed		
ASHRAE design %		
Building and HVAC System		
Peak Load Assumption	Y	Y
Diversity	100%	100%
Redundancy	n/a	n/a
Safety Factor	5%	5%

Envelope Components	Winter U-value (BTU/ s.f. /hr. ° F	Summer U-value (BTU/ s.f./hr. ° F)
Walls below Ceiling	0.074	0.074
Walls above Ceiling	0.074	0.074
Roof	0.051	0.051
Windows	0.870	0.870
Skylights	n/a	n/a
Glass shading coefficient w / wo. blinds	<0.35	
Roof construction type	Built up	

Caltrans District 3 Building						
Space Name	1st Floor	2nd Floor	3rd Floor	4th Floor	5th Floor	Atrium
Square Footage	50980	49915	45432	41409	18641	14455
Typical Occupancy	165	165	140	135	113	3
Maximum Occupancy	170	170	160	150	120	6
Load Assumptions						
Density (ft^2 per person)	100	100	100	100	100	100
Sensible (Btu/h per person)	250	250	250	250	250	250
Latent (Btu/h per person)	200	200	200	200	200	200
Lighting Density W/ ft^2	1.10	1.10	1.00	1.10	1.10	1.10
Equipment Density W/ ft^2	1.00	1.50	1.00	1.00	3.00	1.00

Envelop Components Winter loss (BTU/ s.f. /hr. ° F						
Envelop Components Summer gain (BTU/ s.f. /hr. ° F						
Indoor Environmental Design Conditions						
Heating Dry Bulb Temperature	70	70	70	70	70	70
Cooling Dry Bulb Temperature	74	74	74	74	74	74
Relative Humidity (%)	50	50	50	50	50	50
Maximum duct air velocity FPM	1500	1500	1500	1500	1500	1500
Lighting Illumination (fc)						
Noise Criteria	n/a	n/a	n/a	n/a	n/a	n/a
Air Quality:						
Ventilation Cfm/ s.f.	0.15	0.15	0.15	0.15	0.15	0.15
Outdoor Air (cfm per person)	15	15	15	15	15	15
Air Changes per Hour	n/a	n/a	n/a	n/a	n/a	n/a
Filtration Efficiency per ASHRAE 52						
Space Pressurization - Differential Pressure And Tolerance (IN W.C.)						
In Respect to Adjacent Space						

In Respect to Outside						
Barrier issues between adjacent spaces						

LEED
Standards – including applicable codes, guidelines, regulations, and other references that will be followed.

The project is located in Marysville, California. The building's envelope, mechanical and electrical systems have been designed using the following assumptions which are derived from:

Type	Name of Code/Standard	Why Used
AC Martin Partners	Design standards and/or requirements	
	Standard Practice	
California energy efficiency standards	Title 24	
	LEED™ Green Building Energy Efficiency Goals	
	Energy efficiency goals outlined in the Design Intent Document	
	UBC/UMC/UPC IBC/IMC/IPC	
	NEC	
Professional	ASHRAE Standard 52.1-1992 ASHRAE Standard 15-1994 ASHRAE Standard 55-1992 ASHRAE Standard 62-1999 ASHRAE Standard 110-1995	Filter efficiency and arrestance Mechanical refrigeration safety Comfort criteria Ventilation and Indoor air quality Fume hood performance
	NFPA 90A-1996 NFPA 10-1998 NFPA 13-1996 NFPA 14-1996 NFPA 20-1996 NFPA 24-1995 NFPA 45-1996 NFPA 54-1996	Required, fire protection

	NFPA 70-1999	
	Standard Fire Prevention Code-1997	
	ANSI/CABO A117.1-1998	Plumbing systems
	ADA-1990	Required for accessibility
	ARI 550/590-1998	Factory performance test of one of the chillers
	SMACNA Duct Construction Standards-1995	Standard practice for duct construction
State	ABC State Building Code 1999	Required
Local		

LEED
Narrative Descriptions – including performance criteria for the HVAC&R systems, lighting systems, hot water systems, on-site power systems, and other systems that are to be commissioned.

HVAC Systems and Design Parameters

2.1 General Mech Engr Design Dev

General description of the main HVAC systems and areas served.

System	Areas Served
AC-1	Offices
AC-2	Offices
AC-3	Offices
AC-4	Offices

Why were the above particular systems chosen?

These particular systems were chosen to meet Caltrans District 3 Office Building Replacement Design Criteria and LEED NC v2.2 Gold rating.

Describe the level of priority given to energy conservations for the system.

2.2 Specific System Descriptions

Mech Engr Const Doc

System	Heating / Cooling / Both	Areas Served
AC-1	Both	Offices
AC-2	Both	Offices
AC-3	Both	Offices
AC-4	Both	Offices

What is the rationale for the way the HVAC and lighting were zoned?

The rationale for the way the HVAC was zoned was based upon utilizing the four, 125 ton Roof Top Units while meeting exterior zone load demands. _____

_____

2.3 Load Calculations

Mech Engr Const Doc

What outdoor design conditions were assumed for load calculations?

Summer: DB__90_ WB__73__ Winter: DB__33__

What indoor design conditions were assumed for load calculations?

Summer: DB__72__ RH__50__ Winter: DB__70__ RH__50__

Internal load assumptions: Lighting: _1.10__W/sf. Misc: ___0__W/sf. Other: _____

People/100 sf: _____ Btu/hr/person: sensible _250__, latent _200__

Ventilation: __15__cfm/person. Basis (code, etc.): Code_____

Infiltration: ☐ _____cf,/sf wall area, or ☐ _____ air changes per hour.

Glazing:

	Orientation	% of Wall Area	Overall U	SC
Double Pane	N	0%	0.87	0.59
Double Pane	S	15.8%	0.87	0.59
Double Pane	E	0%	0.87	0.59
Double Pane	W	18.7%	0.87	0.59

What overall safety factor was used and how much diversity was assumed for the heating, cooling plant and fan size?

5% Safety factor & 100% diversity factor _____

_____

_____

For redundant equipment, what redundancy criteria were used?

_N/A_____

_____

Number of sheets attached to this section: _____

AIR DISTRIBUTION SYSTEMS

The building's heating, cooling and ventilation design intent will be met by stand-alone direct expansion (DX) systems with heating supplied by heat pumps. Electronic thermostats and equipment controllers will control the building's HVAC equipment. The air distribution systems are designed using the following rationale:

AC-1 through AC-4

- System Type: Roof Top Water Cooled AC Unit
- Number of Similar Units: 3

Cooling:

- Design Supply Air Temperature: 55°F +/- 1.5°F
- Design Return Air Temperature: 72°F +/- 2°F
- Air Flow (CFM): 50000
- Total Cooling Capacity (MBH): 1780
- Sensible Cooling Capacity (MBH): 1654

Pre-Heating:

- Design Supply Air Temperature: 87°F +/- 0.7°F
- Heating Capacity (MBH): 605-599

Zone Heating:

- Zone Heating Type: RTU
- Design Supply Air Temperature, zone heating: 87°F +/- 0.7°F

Ventilation

- Ventilation Rate (CFM/person): 15
- Ventilation Design Basis: Title 24 requirements

Design Basis:

- Manufacturers: Petra

System Sizing & Efficiency:

- Assumed Safety Factor: 5%
- Assumed Diversity Factor: 100%
- Full load cooling capacity(s) (tons): 125 tons per system
- Full load cooling efficiency(s) (EER): 14.8

DOMESTIC WATER SYSTEMS

The building will be provided with metered potable water service that will be distributed through mains and branches to plumbing fixtures. The building's domestic hot water design intent will be met using the system and design rationale described below:

- DHW System Type: 2 Electric, 1 Gas, and 1 Instantaneous
- Design Entering Water Temperature: 60 °F +/- 5° F
- Design water temperature at fixture: 110°F +/- 5°F
- Manufacturers: A.O. Smith and EEMAX

LIGHTING SYSTEMS

The building will be provided with metered electric service that will be distributed to lighting fixtures through panel boards. The lighting fixtures will be turned on and off by timers and occupancy sensor controls in most spaces.

3.0 Commissioning Plan

Commissioning (Cx) Plan is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Cx Process. The Cx plan was presented to the commissioning team early in the construction process, and all parties involved agreed to uphold it as written. Well written Cx plan results in quality focused process contributing to better project. Cx activities focus on verification of proper design and construction of facility systems and assemblies to meet the Owner's Project Requirements.

Commissioning Plan
For the
Caltrans District 3 Office Building
Located in Marysville, California

Updated June 13, 2008

Prepared by:

Architectural Energy Corporation
2540 Frontier Avenue, Suite 201
Boulder, Colorado 80301

Caltrans District 3 Office Building

Commissioning Plan

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1. Overview

1.1 Abbreviations and Definitions

The following are common abbreviations used in this document.

AE	Architect and design engineers	FPT	Functional performance test
CP	Commissioning Professional	PF	Pre-functional checklist
CC	Controls contractor	MC	Mechanical Contractor
CX	Commissioning	IC	Installing contractor
EM	Energy Manager	GC	General contractor
CX Plan	Commissioning Plan document	Subs	Subcontractors to General
EC	Electrical contractor	TAB	Test and balance contractor
MM	Maintenance Manager	Staff	Maintenance Staff

Where the term “contractors” is used in the CX Plan, it refers to the GC and/or Subs as appropriate.

1.2 Purpose of the Commissioning Plan (CX Plan)

The purpose of the CX Plan is to provide direction for the commissioning process during construction, providing resolution for issues such as scheduling, roles and responsibilities, lines of communication and reporting, approvals, and coordination.

1.3 Commissioning Goals and Objectives

Commissioning (CX) is a systematic process of verifying that the building systems perform according to the design intent and the owner’s operational requirements. All equipment and systems should be installed according to manufacturer’s recommendations, the best practices and standards of the industry, and the Contract Documents.

The CX process facilitates the project team members’ familiarity with design intent and basis of design documents. The owner’s intent and the basis of how this intent is implemented are to be considered by CX team members during construction, acceptance, and warranty phases of the project. The manner of participation of CX team members in commissioning activities is defined in the specifications. Three main goals of the commissioning process are:

1. Facilitate the owner’s greater depth of familiarity with details of the quality of the project delivered at final acceptance.
2. Facilitate the transfer of the project’s technology to the owner’s maintenance staff to optimize operations and maintenance methodology.
3. Document whether and how the comfort systems meet the requirements of the occupants, and the level of efficiency at which that comfort is delivered.

The commissioning process also expedites the following specific objectives:

- Document that equipment is installed and started per manufacturer's recommendations.
- Document that equipment and systems receive complete operational checkout by installing contractors.
- Document system performance with thorough functional performance testing and monitoring.
- Verify the completeness of operations and maintenance materials.
- Ensure that the owner's operating personnel are adequately trained on the operation and maintenance of building equipment.

1.4 Commissioning Scope

The following systems and equipment will be commissioned in this project. All general references to equipment in this document refer only to equipment that is to be commissioned.

System	Equipment
HVAC	
	Packaged AC Units
	Variable Frequency Drives
	Heat Pumps
	Supply and Exhaust Fans
	Pumps
	Variable Air Volume Boxes
	Heat Generation (boilers)
	Heat exchangers
	Cooling Towers
	Testing, Adjusting, and Balancing
	BAS System
Lighting	
	Sweep or Scheduled Lighting Controls
	Daylight Dimming Controls
	Lighting Occupancy Sensors
	Parking lot lighting controls

2. General Building Information

Project Name	Caltrans District 3 Office Building
Project Address	Marysville, CA
Building Use	Office
Square Footage	
Building Description	
Owner	Department of General Services

3. Commissioning Team Information

Function	Name/Address	Contact Info
Commissioning Professional	Architectural Energy Corporation John Wood 2540 Frontier Avenue, Suite 201 Boulder, CO 80301	Tel: 303-444-4149 x204 Cell:303-819-7402 Fax: 303-444-4304 jwood@archenergy.com
Owner		
Project Director	Department of General Services Richard Myren	Tel: (916) 376-1714 Cell:(916) 708-4124 richard.myren@dgs.ca.gov
Construction Manager	Jacobs Engineering Mark Chase	Cell: 916-437-9432 *mark.chase@jacobs.com*
Maintenance Manager	Department of General Services Wes Hubbart	Tel: 916-845-4941 Cell: 916-869-1911 Wes.Hubbart@dgs.ca.gov Fax: 916-845-5477
AE		
Architect	AC Martin Partners	916-646-2890 www.acmartin.com
Electrical Engineer	ACCO	916-852-5050 www.accoes.com
Mechanical Engineer	ACCO	916-852-5050 www.accoes.com

Contractors & Vendors		
General Contractor	Turner Construction Toby Leitch	Cell: 916-202-7359 tleitch@tcco.com
Mechanical Contractor	ACCO Kevin Kiley	Cell: 916-541-5140 kkiley@accoes.com
Electrical Contractor	Helix Electric	925-372-9600 www.helixelectric.com
Air Handling Units	Air Treatment Roy Gale	Cell: 916-719-1329 rgale@airtreatment.com
Lighting Controls	PCI Lighting Control Systems	technical support line 1-800-767-3674.
Test, Adjust, and Balance of air and hydronic systems (TAB)	NABCO Scott Brehmer	916-825-7833 scottb@nabco.biz
Building Systems Control Contractor	Seimens Gary Elnan	510-579-4116 Gary.Elnan@seimens.com

4. Roles and Responsibilities

4.1 General Management Plan

AEC coordinates the commissioning activities and will report to the owner. AEC's responsibilities, along with those of the CX Team, are detailed in the section 01810 of the project specifications. The CX process will require the coordinated effort of all members of the CX Team in order to meet the objectives of the Contract Documents.

4.2 General Descriptions of Roles of the CX Team

General descriptions of the commissioning roles are as follows:

CP:	Serves as Owner's Representative in the CX process, writes and reviews testing plans, directs and documents performance testing.
MM:	Coordinates maintenance staff participation in commissioning activities.
GC:	Facilitates the CX process, ensures that Subs perform their responsibilities and integrates CX into the construction process and schedule.
Subs:	Demonstrate correct system performance.
Staff:	Participate in commissioning tasks and performance testing, review O&M documentation, attend training.
AE:	Perform construction observation, approve O&M manuals and assist in resolving problems.
Mfr.:	Equipment manufacturers and vendors provide documentation to facilitate the commissioning work and perform contracted startup.
Owner:	Responsible for final approval of the CX work.

4.3 Specifications and Commissioning

Commissioning language in the specifications details the scope of commissioning for this project. The following table lists the sections of the specifications that include commissioning related language. Most of these sections include subsections with "Submittal" and "Execution" requirements that are of particular interest in the commissioning process. AEC will review all commissioning-related submittals, and compile a checklist of required Pre-Functional activities based in large part on the "Execution" subsections described in the specifications.

Table 4-1: Specifications with Direct References to Commissioning

Section #	Section Title
013100	Project Management and Coordination
014000	Quality Requirements
017700	Closeout
019113	Commissioning
230800	Mechanical Systems Commissioning
260800	Electrical Systems Commissioning (lighting controls)

4.4 General Management Plan and Protocols

The following communications protocols will be used on this project.

Table 4-2: Specifications Related to Commissioning

Issue	Protocol
For electronic or verbal information and clarifications:	AEC goes direct to informed parties.
For recommendations to the design team	AEC goes direct to AE and/or owner.
For notifying contractors of deficiencies:	AEC documents deficiencies through the owner, but may discuss deficiency issues with subcontractors prior to notifying the owner.
For scheduling functional tests or training:	AEC provides input and coordination of testing and training. Scheduling is done through the GC.
For scheduling formal commissioning meetings:	AEC selects the date and schedules through the owner and/or GC.
For making a request for significant changes:	AEC has no authority to issue change orders.
For making minor changes in specified sequences of operations:	All changes in sequences of operations required must be approved by the AE. AEC may recommend changes in sequences of operation to correct operational deficiencies and/or to improve efficiency or control.
Subcontractors disagreeing with requests or interpretations by AEC shall:	Resolve issues at the lowest level possible. First with AEC, then with the GC and owner. Some issues may require input from the AE.

4.5 Commissioning Team Responsibilities

The responsibilities of various parties in the commissioning process are provided in this section.

4.5.1 Commissioning Professional (CP)

AEC is not responsible for design concept, design criteria, code compliance, general construction scheduling, cost estimating, or construction management. AEC may assist with problem-solving deficiencies, but ultimately that responsibility resides with the GC and the AE team. The primary role of AEC is to develop and coordinate the execution of a testing plan to verify and document that systems are installed and functioning in accordance with the design intent and the Construction Documents.

Construction and Acceptance Phase

- Coordinates and directs all commissioning activities. Work with the GC and owner to ensure that commissioning activities are scheduled.
- Maintain an up-to-date CX Plan.
- Plan and conduct the commissioning CX plan discussion meeting.
- Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures, and sequences of operation.
- Review Contractor submittals applicable to commissioned systems, concurrent with the AE reviews.
- Verify subcontractor start-up and checkout plans. Coordinate and verify execution of pre-functional checklists.
- Perform site visits, as necessary, to observe component and system installations. Attend construction job-site meetings, as necessary, to monitor construction and commissioning progress.
- Review and spot check completed pre-functional checklist and start-up reports.
- Assist with coordination of start-up requirements with TAB requirements.
- Write or review and be final editor of functional performance test procedures for equipment and systems.
- Coordinate, witness, and document functional performance tests performed and demonstrated by installing contractors. Coordinate retesting as necessary until satisfactory performance is verified.
- Maintain a master deficiency and resolution record. Provide the GC and Owner with written progress reports, recommended actions, and resolution results.
- Review the training proposed by the contractors for the Owner's operating personnel.
- Provide signage to facilitate O&M awareness of experimental components of the mechanical and electrical systems.

- Review the O&M manuals.
- Prepare a final commissioning report.

Warranty Period

- Coordinate and supervise required short-term monitoring, seasonal or deferred testing and deficiency corrections.
- Conduct a Near End of Warranty Review

4.5.2 Design Team (AE)

Construction and Acceptance Phase

- Attend CX plan discussion meeting and additional meetings, as necessary.
- Provide design intent and sequence of operation documentation as required by AEC.
- Witness selected functional performance testing.
- Assist in resolution of deficiencies identified during commissioning.
- Incorporate commissioning deficiency list into final punchlist
- Review and approve the operations and maintenance manuals.
- Optional: Review equipment start-up and pre-functional checklists. Review functional performance test plans.

Warranty Period

- Assist in resolution of system deficiencies identified during warranty period commissioning.

4.5.3 Owner (OWN)

Construction and Acceptance Phase

- Arrange for facility operating and maintenance personnel to participate in commissioning activities and training sessions.
- Provide final approval for the completion of the commissioning work.

Warranty Period

- Work with GC and CP to facilitate short-term monitoring seasonal and deferred testing and to address deficiency issues.

4.5.4 General Contractor (GC)

Construction and Acceptance Phase

- Facilitate the coordination of the commissioning work by AEC.
- Organize, facilitate, and attend CX plan discussion meeting and additional meetings, as necessary.
- Furnish copies of construction documents, addenda, change orders, and submittals related to commissioned equipment to AEC.

- Ensure that Subs execute their commissioning responsibilities according to the Specifications and CX Plan.
- Furnish AEC with updated startup schedules as soon as they become available
- Coordinate the training of owner personnel.
- Prepare O&M manuals, according to the Specifications, including updating original sequences of operation to as-built conditions.

Warranty Period

- Ensure that Subs execute required seasonal or deferred functional performance testing.
- Ensure that Subs correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified during the warranty period.

4.5.5 Mechanical, Electrical, Controls, TAB, and Installing Contractors

Construction and Acceptance Phases

- Attend commissioning CX plan discussion meeting and additional meetings, as necessary.
- Assist in clarification of operation and control of commissioned equipment where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- Develop a start-up and checkout plan for all commissioned equipment based on manufacturer's recommendations and contract documents. Submit to AEC for review and approval *prior to startup*.
- TAB contractor to perform design review for "balanceability" and provide a preliminary (i.e. blank) report including:

  -TAB procedures to be used on each system (including ambient condition requirements at time of test for each test of each system),

  -list of calibrated equipment,

  -copies of pump curves,

  -drawings with diffuser numbers to coordinate the data sheets,

  -drawings with circuit setter numbers to coordinate the data sheets,

  -readiness checklist (to verify systems are ready for balancing)
- Perform and clearly document all startup and system operational checkout procedures.
- Resolve AE punch list items before functional testing. Control Contractor checkout of points and sequences to be complete prior to TAB on any system or equipment. Air and water TAB shall be completed with discrepancies and problems resolved before functional testing on any system or equipment.

- Facilitate and participate in functional performance testing, under the direction of AEC, for commissioned equipment.
- Resolve equipment or system deficiencies and retest as required to verify modified performance.
- Prepare O&M manuals according to the Specifications, including updating original sequences of operation to as-built conditions.
- Provide training of the Owner's operating personnel as specified.
- Coordinate with equipment manufacturers to determine requirements to maintain the validity of warranties.

Warranty Period

- Execute seasonal or deferred functional performance testing, as necessary.
- Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified during the warranty period.

4.5.6 Controls Contractor

The commissioning responsibilities of the controls contractor during construction and acceptance phases are:

1. <u>Sequences of Operation Submittals.</u>

   The temperature controls submittals shall include complete and detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

   a. A narrative description of the system, describing its purpose, components and function.

   b. Interactions and interlocks with other systems.

   c. Delineation of control interactions between packaged controls and the building automation system, including a listing of monitored points, controlled points, and adjustable points.

   d. Written sequences of control for packaged controlled equipment.

   e. Sequences of control for all modes of operation (Start-up, Warm-up, Cool-down, Normal occupied, Unoccupied, Emergency Shutdown, etc.).

   f. Capacity control sequences and equipment staging.

   g. Temperature and pressure control sequences (setbacks, resets, etc.).

   h. Sequences for all control strategies (economizer control, optimum start/stop, optimization, demand limiting, etc.).

   i. Effects of power or equipment failure with all standby component functions.

   j. Sequences for alarms and emergency shutdowns.

k. Seasonal operational requirements.

2. Control Drawings Submittal

a. The control drawings shall have a key to all abbreviations.

b. The control drawings shall contain graphic schematic depictions of the systems and each component.

c. The schematics will include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

d. Provide a full points list with at least the following included for each point:

1) Controlled system
2) Point abbreviation
3) Point description
4) Point type (digital/analog, input/output)
5) Display unit
6) Control point or setpoint (Yes / No)
7) Monitoring point (Yes / No)
8) Intermediate point (Yes / No)
9) Calculated point (Yes / No)

3. An as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
4. The controls contractor shall prepare a written plan indicating in a step-by-step manner the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing.
5. Provide a signed and dated certification to AEC and GC upon completion of the control system checkout.
6. Facilitate and participate in functional testing activities.
7. Facilitate and participate in short term monitoring activities. Including providing Commissioning Professional with software, passwords, and/or specialized hardware to collect trends and monitor the systems over the internet.

4.5.7 Equipment Suppliers

- Provide requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in effect.
- Provide information requested by CP regarding equipment sequence of operation and testing procedures.
- Assist in equipment startup and testing per agreements with installing contractors.

5. Commissioning Process

This section sequentially details the commissioning process by commissioning task or activity.

5.1 Prepare Draft Commissioning Plan

This is compiled and distributed before the commissioning team members meet to discuss the plan.

5.2 Documentation of Owner's Project Requirements and Basis of Design

(please also see AE responsibilities)

A clear set of Owner's Project Requirements (OPR) is critical to the commissioning process. OPR define the benchmark for system performance. The OPR is a detailed explanation of the information developed for the owner's program, focused on those systems included in the scope of work for commissioning. It will clearly define functional and indoor environmental quality requirements.

The Basis of Design Report details the design team's response to the performance criteria in owner's program and project requirements. It will include the heating, ventilation, lighting, air-conditioning parameters and requirements, for each occupancy type, with references to applicable codes and standards, and other design criteria used as the "basis of design" for other building systems to be commissioned.

AEC continues to provide OPR and basis of design templates to the design team for clarification of intent, parameters, etc. This effort is slightly in arrears. It would be best not to have to deal with the OPR/BOD on a question by question basis as they arise in the field. OPR and basis of design is best considered, and articulated in advance, and compiled in a comprehensive, written document for distribution in advance of construction to project team members. AEC continues to request that these documents be prepared and delivered to AEC for review, discussion, and distribution to team members prior to the CX plan discussion meeting per schedule in section 6.3.

5.3 Develop Commissioning Specifications

This happens early in design phase commissioning.

5.4 Design Review at 95% Construction Documents and Design Changes

95% CD review happens toward the end of design phase commissioning. The Commissioning Design reviewing process continues as design changes are made. Commissioning design recommendations are to be evaluated and implemented as appropriate by the owner, the contractor and the engineer.

5.5 Commissioning CX plan discussion Meeting

The CX plan discussion meeting brings together all members of the design, construction, and operations team that will be involved in the commissioning process. The coordination of commissioning activities to coincide with the completion of mechanical systems is discussed. Each building system to be commissioned is addressed, including commissioning requirements, and completion and start-up schedules for each area. During the CX plan discussion meeting, all commissioning team members are involved in decisions regarding the scope of work, tasks, schedules, deliverables, and responsibilities for implementation of the CX Plan.

5.6 Commissioning Plan (CX Plan)

AEC finalizes the draft CX Plan using the information gathered from the CX plan discussion meeting. The initial commissioning schedule is also developed along with a detailed timeline. The timeline is fine-tuned as construction progresses. The GC is requested to update AEC regularly with construction schedules, and to include pre-functional checkout and functional performance testing in the master schedule.

5.7 Submittals Review

The GC will provide AEC with a set of equipment and system submittals. AEC will review the submittals for completeness and check that the submitted equipment meets the design requirements and design intent.

The preferred, and requested, medium for submittal data submission is electronically and by email. This submitted equipment data is to include installation and start-up procedures, operation and maintenance data, performance data and temperature control drawings.

The GC, Subs, or AE notify AEC of any new owners project requirements or operating parameter changes, added control strategies and sequences of operation, or other change orders that may affect commissioned systems.

AEC review comments will get forwarded to the design engineer of record and copied to the submitting Contractor for consideration of that particular system. The design engineer then delivers a formal submittal response and copies the Contractor as well as well as the Commissioning Professional. If a resubmittal is requested, the process repeats itself. If no complete resubmittal is require, but addendum are required before delivery of equipment, the process repeats itself.

5.8 Site Visits

AEC will make periodic site visits to witness equipment and system installations. Each site visit will have a specific agenda and will be coordinated with the GC site supervisor. AEC attends selected planning and job-site

meetings in order to remain informed on construction progress and to update parties involved in commissioning.

5.9 Pre-functional Checklist

The pre-functional checklist is described in paragraph 7 below.

5.10 Functional Performance Testing

Functional performance testing is described in paragraph 8 below.

5.11 Short-Term Monitoring

Short-term monitoring, using data acquisition equipment or building automation system trends to record system operation over a two to three week period, will be used to investigate the dynamic interactions between components in the building system.

The monitoring occurs after occupancy to evaluate the building systems' performance under natural occupancy and ambient load conditions. The objectives of the monitoring are to evaluate scheduling, the interaction between heating and cooling, and the effectiveness of the system in meeting the comfort requirements of the occupants.

Either the building automation system or AEC Microdataloggers or both will be used to take data on selected systems. This occurs after occupancy, and any further deficiencies identified from this testing will be reported to the team for correction.

5.12 Deficiency Report and Resolution Record

All deficiencies found during site visits and functional performance testing will be documented in a commissioning "Issues Log." The report will include all details of the components or systems found to be non-compliant with the parameters of the functional performance test plans and design documents. Unresolved deficiencies will become part of the AE punch list. The report will detail the adjustments or alterations required to correct the system operation, and identify the responsible party. The deficiency report will be continuously updated. AEC schedules any required re-testing through the GC. Decisions regarding deficiencies and corrections are made "on-the-fly" as much as possible, preferably between AEC, sub-contractor and the GC.

5.13 Operations and Maintenance Manuals, Training and Signage

Manuals: The operation and maintenance manuals prepared by the contractors for the owner's maintenance personnel are reviewed for completeness. The contractors are encouraged to submit O&M manuals at the earliest possible date. Materials may be added, or requested from the

contractors, to stress and enhance the importance of system interactions, troubleshooting, and long-term preventative maintenance and operation.

Training: Effective training of maintenance personnel is critical to the long-term performance of the new building. For each training session, the contractors provide a detailed agenda for each piece of equipment or system for which training is required. The agenda describes the training scope, duration, and methods, along with the name and qualifications of the trainers. The trainer documents each training session (duration, general subjects covered, and attendees). AEC may witness and contribute to any of the training sessions, but may not be present for all training. It is highly recommended that owner staff responsible for maintenance of the facility witness at least one sample of each equipment type functional performance test. This serves to visually, and tangibly familiarize the owner's maintenance staff with each sequence of operation of each piece of equipment.

5.14 Final Commissioning Report

The final Commissioning Report will be submitted to the Owner summarizing all of the tasks, findings, and documentation of the commissioning process. The report will address the actual performance of the building systems in reference to the design documents. All test reports by various sub-contractors, manufacturers and controlling authorities will be incorporated into the final report.

The commissioning report includes:

- OPR and BOD (paragraph 5.2)
- Submittal Reviews (paragraph 5.7)
- Compilation of pre-functional documentation (paragraph 7)
- Functional test procedures and results (paragraph 8)
- Deficiencies that were discovered and the measures taken to correct them (paragraph 5.12)

5.15 Conduct End-of-Warranty or Post-Occupancy Review

AEC will return to the site before the end of the warranty period to review the current building operation with the facility maintenance staff. The review will also include any outstanding issues from original or seasonal testing. The commissioning provider will interview facility staff to identify concerns with building operation and provide suggestions for improvements. In addition, the commissioning provider may help identify issues that relate to the original warranty and assist staff in developing reports or documentation to remedy any problems.

6. Scheduling

6.1 General Issues

The following is a scheduling guideline for functional testing:

1. The scheduling of HVAC commissioning activities will be coordinated to coincide with the completion of HVAC systems and the related pre-functional documentation (paragraph 7). Functional Performance Testing activities that address the interaction between systems will occur upon completion of all controls related construction. During these tests, TAB flows will be verified while the systems are operating in various modes.
2. Scheduling of lighting control, photovoltaic, wind-power, Cogeneration (Microturbines and Absorption chiller) refrigeration, skylight, and irrigation commissioning testing (if applicable) will occur once the installing contractors have completed their pre-functional checklists and performed their own tests and the systems are documented as ready to be turned over to the owner. Commissioning activities that address the interaction between systems will occur upon completion of all controls-related construction and pre-functional documentation (paragraph 7).

6.2 Special Notes

1. Equipment should not be started until pre-functional checklist items and all manufacturer's pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.
2. Manufacturer's startup procedures will be followed and documented on manufacturer-provided documentation. The installing contractor will collect and insert this information into the pre-functional (PF) binder and complete all other equipment checklists. The PF binder will be complete for that piece of equipment prior to undertaking its functional performance tests (FPT). A manufacturer's startup technician rather than a third party company, or the installing contractor, shall perform startup of equipment.

3. Functional performance testing does not get scheduled to begin until all pre-functional checklists (controls as well as installation and startup forms) are complete and submitted for review. Since TAB is typically a checkpoint of the Installing contractor's PF checklist, completion of the PF checklist will indicate that TAB is complete and all TAB deficiencies corrected. There may even be a check box to verify this as well. Such a box is included in the sample checklist below.
4. HVAC systems: The functional performance tests will involve the general contractor, installing contractor (typically the MC), TAB contractor, controls programmer and/or designer, Owner's maintenance personnel. It is recommended that the mechanical engineer attend to verify that the systems meet the design and to provide quick resolution to questions that arise.
5. Lighting systems: The functional performance tests will involve the general contractor, installing contractor (typically the EC), controls programmer and/or designer, Owner's maintenance personnel. The electrical engineer should attend to verify that the systems meet the design and to provide quick resolution to questions that arise.

6.3 Activity Schedule

Preliminary Commissioning Schedule:

Activity	Date
OWNER/AE OPR Document	On-going through Final Report with most complete prior to CX plan discussion meeting
AE BOD Document	On-going through Final Report with most complete prior to CX plan discussion meeting
AEC Submittal Reviews	Concurrent with AE review
AEC Development of CX Plan with CX team input	On-going thru project
AEC and contractor Development of Functional Performance Tests (CX Team Review)	
Contractors Complete Pre-Functional Tasks with exception of some controls and TAB work (PF not fully complete until controls and TAB complete and TAB deficiencies corrected where applicable).	
Controls installation, points list, programming, and sequence checkout complete (hydronics systems only).	
Controls installation, points list, programming, and sequence checkout complete (all). Controls software, monitoring and trending capabilities furnished to CA.	
Testing Adjusting, and Balancing of Air Systems	
AEC, Contractors, AE, and O&M Staff undertake Functional Performance Tests	
AEC Assembles Short-Term Monitoring Analyses	
AEC Reviews O&M Manuals and As-Builts	
CX Team Resolves Master List of Deficiencies	
AEC conducts CX Near End of Warranty Review	
AEC Issues Final CX Report	

7. Pre-Functional Notebook and FPT readiness checklist

AEC or ACCO will develop checklists to facilitate documenting that all pre-functional (PF) checkouts, startups, and testing have been coordinated and completed by the appropriate parties. AEC or ACCO will also develop a binder to compile copies of all related installation and startup documentation required by the contract documents. AEC will not schedule or undertake functional performance testing (FPT) for any equipment or system until copies of all related pre-functional documentation have been delivered to AEC in the binder provided with signatures on the FPT readiness checklist provided.

Below are some figures with examples of the type of checklists to be completed by the contractors. Figure 1 below is an example of a PF Verification Form which serves to communicate readiness for functional performance testing. Figure 2 is an example of a lighting system PF and FPT checklist. Figure 3 is an example of a HVAC equipment Mechanical PF checklist. Figure 4 is an example of a HVAC equipment Control PF checklist. Binders will be provided to the GC for organizing all PF completion and FPT readiness documentation.

The pre-functional binder is to initially contain blank forms of all equipment tests and inspections such as ductwork or piping pressure tests, manufacturer's installation and startup checklists, controls point to point checklists, control as-built drawings, TAB report, etc. When all these lists and reports are completed on a system, FPT can begin on that system.

Pre-functional Test Verification Form

Facility Name: **Sample CX Project** ***Tuesday, April 26, 2005***

Please initial and date as the required tasks are completed so that we will know that systems are ready for functional performance testing.

Please fax this list once a week and as soon as all items are complete.

Equipment Name	*Drawing Number*	*Area Served*	*General Contractor Prefunctional checklist Complete*	*Installing Contractor Prefunctional checklist Complete*	*Controls Contractor Prefunctional checklist Complete*
1 HVAC system equip	M4	sample			
2 HVAC system equip	M4	sample			
BIPV Systems	E series	All			
Irrigation System	NR series	Landscaping			
Lighting systems	E series	All			
Microturbine System	E series	All			
Refrigeration system	R series	Grocery			
Skylight Systems	A series	Interior			
Wind Power system	E series	All			

Figure 1. Sample PF Verification checklist (a.k.a. FPT readiness checklist)

Lighting Space Summary

Facility Name: **Sample CX Project** ***Friday, April 29, 2005***

Spaced Served					*Space Notes*						
Drawing #	*Circuit #*	*Design f*	*Actual fc*	*Area*	*Watts*	*LPD*	*Fixture Type*	*# Fixtures*	*Controls*	*PF*	*FPT*	*Notes*
Sample Area												
Space 1												
E1	C1	10		100	90	0.90	DF	2	Dimming Photocell, Time Clock	☐	☐	
E1	C1	10		100	90	0.90	DF	1	Emergency	☐	☐	
Space 2												
E2	C2	20		0	120	0.00	AB	4	Astronomical, Dimming Photocell, Occupancy	☐	☐	
E2	C2	20		0	120	0.00	AC	2	Emergency	☐	☐	
Space 3												
E3	C3	30		300	320	1.07	CF	8	Timed Override, Dimming Photocell, Time Clock	☐	☐	

Figure 2. Sample lighting Verification checklist

Pre-functional Test Verification Form: Mechanical

Facility Name: Sample CX Project

Equipment Name	*Location*	*Area Served*	*Drawing No*	*Manufacturer*	*Model No*
1 HVAC system equip		sample	M4		

General: To be filled out by installing contractor, and kept onsite during project. The checklist will be completed and turned in prior to Functional Performance Testing.

Instruction: Fill in Unit Information as as listed below, then check the appropriate box as as items are verified and deemed acceptable. Add comments if needed and explain any exceptions taken.

Installation Checks	*Contractor*			
	Yes	*No*	*N/A*	*Comment*
Casing condition OK, free of dents	☐	☐	☐	_____
Electrical service to fan is complete	☐	☐	☐	_____
Mounting correct, shipping bolts and packing materials removed	☐	☐	☐	_____
Permanent labels affixed (equipment TAG, manufacturer's model, serial numbers)	☐	☐	☐	_____
Manufacturer's installation manual followed for installation and startup procedures	☐	☐	☐	_____
Copy of initialed Manufacturer's procedures attached	☐	☐	☐	_____
TAB complete with deficiencies noted and corrected	☐	☐	☐	_____
Signature on CX PF Verification summary checklist (mechanical entry)	☐	☐	☐	_____

Notes _____

_____

_____

*****By signing, I have verified that the above equipment is installed per the manufacturer's instructions, and the design documents, and is ready for final testing by the commissioning agent.***

Signature**		*Date*
Mechanical Contractor	_____	_____
General Contractor	_____	_____

Figure 3. Sample HVAC equipment Mechanical PF checklist

Pre-functional Test Verification Form: Controls

Facility Name: Sample CX Project

Equipment Name	*Location*	*Area Served*	*Drawing No*	*Manufacturer*	*Model No*
1 HVAC system equip		sample	M4		

General: To be filled out by installing contractor, and kept onsite during project. The checklist will be completed and turned in prior to Functional Performance Testing.

Instruction: Fill in Unit Information as as listed below, then check the appropriate box as as items are verified and deemed acceptable. Add comments if needed and explain any exceptions taken.

Installation Checks	*Contractor*			
	Yes	*No*	*N/A*	*Comment*
Safety interlocks wired and tested	☐	☐	☐	
Start/stop wiring complete	☐	☐	☐	
Status sensor and wiring complete	☐	☐	☐	
Copy of completed point to point checkout attached	☐	☐	☐	
Software programming complete	☐	☐	☐	
Alarms programmed and tested	☐	☐	☐	
Sequences tested to meet specified sequences	☐	☐	☐	
Graphics complete and installed	☐	☐	☐	
Trends enabled	☐	☐	☐	
Signature on CX PF Verification summary checklist (control entry)	☐	☐	☐	

Notes _____

***By signing, I have verified that the above equipment is installed per the manufacturer's instructions, and the design documents, and is ready for final testing by the commissioning agent.*

Signature**		*Date*
Controls Contractor	_____	_____
General Contractor	_____	_____

Figure 3. Sample HVAC equipment controls PF checklist

8. Functional Performance Tests

Functional performance testing verifies the intended operation of individual components and system interactions under various conditions and modes of operation. The systems are run through all of the sequences of operation and the response of components is verified. Testing proceeds from components to subsystems to systems, and finally to interlocks and connections between systems.

Architectural Energy Corporation (AEC) prepares or reviews functional performance test plans so that the complete sequence of operations is included. AEC obtains all documentation, including an updated points list, control sequences, and setpoints. If necessary, AEC may request clarifications from contractors and the design team regarding sequences and operation.

Prior to execution of the FPT, AEC provides a copy of the testing plan to the Commissioning Team to review the tests. The CX Team review is primarily to verify the feasibility of the tests, but also to determine the test safety, as well as warranty and equipment protection.

AEC schedules functional tests with the assistance of the GC and Subs. Under the supervision of AEC, the installing Subs perform the hardware and/or software manipulations required for the testing. Owner maintenance staff and the AE should also be present in order to assist in system observations. AEC witnesses and records the results of functional performance testing.

Functional testing will occur on all systems identified for commissioning in paragraph 1.4. On the following page is a sample Hydronic Unit Heater functional performance test developed by AEC.

Flow rates (air and hydronics) are also to be verified using a TAB FPT plan.

Trending is integrated into the FPT plan to observe and monitor that system is optimized.

Functional Performance Testing Procedure

Title:	Hydronic Unit Heaters - with remote temperature sensor, DDC setpoints and override timer	
Equipment Tag:	UH-1	
Participants:	**Name**	**Organization**
Date:		
Comments:	{1} Coordinate temperature controls so that the UH fan is energized and hydronic heating coil is opened upon a drop of output from the remote mounted temperature sensor below DDC setpoint or override timer button is pressed. With no call for heat, the valve closes and the fan stops. {2} Coordinate appropriateness of location of temperature sensor per unit heater with commissioning agent and engineer. {3} Recommend that an alarm is registered at the DC front end if the temperature is excessively low. {4} Recommend a discharge air sensor and fan status current transducer be added to trend points to determine and monitor proper operation.	
Sequence Events:	Unit Heater to prevent excessivlely low temperatures in receiving area. See CPC submittal and FPT events for sequence elaboration. Event #1 Thermostat heating Event #2 Satisfied condition (no call for heat or timed override) Event #3 Override timer operation Event #4 Alarms and safeties	

Record time-of-day schedule setpoints and note any deviation from DESIGN.

	SCHEDULE	NOTES
Monday	Occupied	
Tuesday	Occupied	
Wednesday	Occupied	
Thursday	Occupied	
Friday	Occupied	
Saturday	Occupied	
Sunday	Occupied	
Holiday	Occupied	

DDC Parameters	UH-1
Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design ().	
Parameter	**Value programmed in BAS**
Timed override button duration = **120 minutes**	
Low Space temperature alarm = **50°F**	
Space Setpnt = **66°F**	

Sensor Location Checks			UH-1
Verify that sensors are adequately located and not effected by other elements of the system.			
Sensor	**Plan Location**	**Actual Location**	**Notes**
ZAT Sensor	Receiving Area served by UH-1		
Fan Status CT	UH-1 electric feed		
DAT Sensor	UH-1 discharge		

Functional Performance Test

Title:	Hydronic Unit Heaters - with remote temperature sensor, DDC setpoints and override timer
Tag:	UH-1

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
		1	Simulate call for heat (timer off)	Fan energizes and hydronic heating coil valves open	
		2	Force ZATsp low to simulate a satisfied temperature (timer off)	Fan stops and hydronic heating coil valves close	
		3	Force ZATsp low to simulate a satisfied temperature. Turn on override timer.	Fan energizes and hydronic heating coil valves open	
		3	with cold spray, cool zone space sensor to below 49°F, or change alarm setpoint to be above the current space temperature	Alarm is generated at DDC front end	

Functional Performance Test - DDC TRENDING

System:	Hydronic Unit Heaters - with remote temperature sensor, DDC setpoints and override timer
Title:	Temperature, and timed manual override
Tag:	UH-1

Pass	Fail	Trend #	Description of Trend	Expected Results	Remarks
		1a	UH valve position (either open or closed or % open) every 2 mins for two days including times of satisfied conditions and occupied heating.	Efficient heat delivery to the space and proper temperature control with no hunting	
		1b	UH fan status every 2 mins for two days including times of satisfied conditions and occupied heating.	Efficient heat delivery to the space and proper temperature control with no hunting	
		1c	Timed override use event log for two days including times of occupied, unoccupied, cooling and heating.	Efficient heat delivery to the space and proper temperature control with no hunting	
		1d	ZAT every 2 mins for two days including times of occupied, unoccupied, cooling and heating.	Efficient heat delivery to the space and proper temperature control with no hunting	
		1e	ZATsp every 2 mins for two days including times of occupied, unoccupied, cooling and heating.	Efficient heat delivery to the space and proper temperature control with no hunting	

Abbreviation	Elaboration
cfm	cubic feet per minute (volumetric flow rate, typically air)
CHWCEAT	chilled water coil entering air temperature (°F)
CHWCLAT	chilled water coil leaving air temperature (°F)
CHWRT	chilled water return temperature (°F)
CHWST	chilled water supply temperature (°F)
DAT	discharge air temperature (°F, dry bulb)
DATdp	discharge air dew point temperature (°F)
DATsp	set point of the discharge air temperature (°F, dry bulb)
DDC	direct digital control
dp	dew point (abbreviated suffix)
DX	Direct Expansion cooling.
FPT	Functional performance test
gpm	gallons per minute (volumetric flow rate, typically water)
HMI	human machine interface (DDC speaks to this PLC device via modbus)
HWRT	heating water return temperature (°F)
HWST	heating water supply temperature (°F)
MAT	mixed air temperature (°F, dry bulb)
MATSP	set point of the mixed air temperature (°F, dry bulb)
OA	outside air
OA ent	outside air enthalpy (btu/lb)
OAT	outside air temperature (°F, dry bulb)
Occ	occupied or occupancy
PF	Pre-Functional checks
RAT	return air temperature (°F, dry bulb)
RAT rh	return air relative humidity (%rh)
SP	space static pressure differential (with respect to outside or other reference)
sp	set point (abbreviated suffix)
Unocc	unoccupied
ZAT	zone air temperature (°F, dry bulb)
ZAT dp	zone air dew point temperature (°F)
ZATdpsp	zone air dew point temperature (°F) set point
ZATsp	zone set point (°F, dry bulb)

4.0 Design Reviews & Submittal Reviews

Design and submittal review contained in this section were written by AEC staff in compliance with LEED Enhanced commissioning requirements. Design/Construction Team responses to reviews issued by CxA are also included in this section.

HVAC system review should include:

• Review of site design conditions for potential impact on system performance (e.g., are systems suitable for climactic conditions at that site, as defined by ASHRAE)

• Major IAQ issues including: temperature/humidity control, filtration, ventilation control.

• HVAC and envelope interactions pressure relationships (e.g., are depressurized areas of the building located adjacent to exterior walls where infiltration may cause problems)

• Clarity of the control sequences of operation, including emergency responses

• Controls submittal requirements and clarity of control responsibility between equipment manufacturer and central system controls

• Ability of the system to be commissioned

• Sufficient points and features in the control system

• Adequate space for installation, testing, operation and maintenance access

• Equipment redundancy requirements, if necessary

• Reality check of system sizing

Electrical System review should include:

• Lighting controls – functionality and energy efficiency

• Daylight dimming control systems are clearly shown and specified

MEMORANDUM

ARCHITECTURAL ENERGY
C O R P O R A T I O N
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San Francisco, California 94105
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FAX (415) 957-1381

TO: Richard Myren, DGS/PMB

CC: Ken Adams & Mark Case, Jacobs
Lowell Shields, Capitol Engineering
Bill Finney, RMW
Norman Bourassa, California Energy Commission
Scott Hixon, DGS/BPM
Daniel Burgoyne, DGS

FROM: Erik Kolderup
Derek Kmicikiewicz

DATE: September 28, 2006

SUBJECT: Caltrans District 3 Office – Commissioning Design Review

Architectural Energy Corporation (AEC) is serving as commissioning authority for this project on behalf of DGS and under contract with the CEC. Per Part 3, Section 7 "Building Commissioning" in the Design Guidelines the commissioning authority performs a design review at several stages: schematic design, design development, 50% construction documents, and 95% construction documents.

This memo lists AEC's comments based on the following:

- Turner's September 21, 2006 "systems confirmation" submittal
- Presentation by Turner and design/build team members at a September 26, 2006 meeting
- (AEC did not receive plans or specs to accompany the submittal narrative)

Please note that this review focuses on energy performance and is not comprehensive for compliance with the overall Design Guidelines and Performance Criteria.

As a general comment, it appears that the contractor is doing a good job of developing an energy efficient design and performing early energy modeling analysis to inform the design.

	Comment	Reference
1.	Solarban 70XL seems to be an appropriate choice for energy and daylighting performance.	Submittal B20, p. 2 of 3
2.	Thermally broken aluminum window framing (identified in the submittal as US Aluminum FT-451 and FT-601) are desirable choices for energy and comfort performance.	Submittal B20, p. 2 of 3

3.	The system described in the “Core HVAC Systems” section is reasonable and appropriate.	Submittal D30, p. 1 of 3, “Core HVAC Systems”
4.	The submittal describes 35% prefilters and 85% final filters, as called for in the RFP, but the design/build team should consider MERV 13 final filters to help achieve LEED indoor environmental quality credits.	Submittal D30, p. 1 of 3, “Core HVAC Systems”
5.	What is the minimum pressure at which the fabric ducts can operate while still maintaining good air distribution (e.g. no dumping)? The submittal mentions that they operate at 0.5 in. w.c. If this is higher than a comparable sheet-metal duct, then are the potential savings due to static pressure reset control going to be lower with the fabric ducts? Presumably, the pressure upstream of the VAV boxes should be able to drop as low 0.5 in. during low-load periods with static pressure reset controls, and the pressure in the fabric ducts would be lower.	Submittal D30, p. 2 of 3, “Tenant Distribution System”
6.	Consideration should be given to separate evaporative cooling of makeup air for the kitchen rather than serving with the same conditioned air as the dining area. The RFP states, “Provide for energy-efficient makeup air system” (24.C.6.f.3).	Submittal D30, p. 2 of 3, “Café Systems”
7.	Minor detail: statement regarding 100,000 hour lamp life appears to be a mistake.	Sustainable Design, p. 4 of 11
8.	Carbon Dioxide Sensing. The submittal states that CO_2 will be sensed at the return of each air handling unit to control outside air. Please note that sensing within the individual spaces is likely necessary to achieve LEED credits and meet Title 24 requirements for high occupancy spaces.	Sustainable Design, p. 6 of 11
9.	System Right Sizing. We agree that avoiding oversizing of cooling compressors and VAV boxes can improve energy performance. However, other forms of oversizing can improve performance, such as larger air handler dimensions (filter and coil face area), air shafts, air ducts, and pipes.	Sustainable Design, p. 7 of 11
10.	Green Power. The State should be aware that the contractor is assuming the State will pay for green power certificates to earn LEED credits. However, this is not a very large investment.	Sustainable Design, p. 7 of 11
11.	The submittal describes a proposed goal of 20% energy savings below Title 24-2005. However, the RFP lists a goal of 25%, and the contractor’s proposal included a LEED scorecard indicating 5 credits for energy performance, equal to at least 24.5% savings.	Sustainable Design, p. 10 of 11
12.	Some of the measures listed as “further enhancements (to baseline designs) were also listed in the RFP Design Guidelines (24.C.8) as design features for the contractor to consider in meeting the 25% energy savings goal. Therefore, it seems that they should not necessarily be presented as additional cost items if they are necessary to meet the overall performance goal listed in the RFP. This comment applies to daylight harvesting system, reduced friction loss in ducts and pipes, and pre-cooling outside air.	Sustainable Design, p. 11 of 11

13.	Automatic daylighting controls with dimming ballasts were included in the contractor's original submission (Section E Sustainable Design Enhancements). Therefore, it seems inappropriate to include them in this submission as a potential extra cost item.	Sustainable Design, p. 11 of 11
14.	Data center airside economizer and related alternatives seem worthy of further study. Caltrans information technology personnel should be consulted for their requirements.	Sustainable Design, p. 11 of 11
15.	Comfort in perimeter zones. The contractor should confirm that occupant comfort will be maintained in perimeter zones. One issue of potential concern is radiant temperature of the uninsulated concrete columns and beams. Another potential concern is the depth of the perimeter zone served by the fabric duct system and the fact that extra heating or cooling might be needed near the exterior wall relative to space more than 15 feet from the exterior wall.	9/26/06 meeting discussion
16.	Comfort and air quality in spaces near the "canyon". Contractor should confirm that adequate ventilation air and comfortable air temperature will be maintained in workstations close to the open core.	9/26/06 meeting discussion
17.	In a future submittal, contractor should provide details of building pressure control scheme that accounts for the impact of the open "canyon" space.	9/26/06 meeting discussion
18.	Alternatives to R-22 refrigerant should be considered.	9/26/06 meeting discussion
19.	Contractor should work with Caltrans to determine requirements for off-hour control capability and to maximize the HVAC and lighting system capability to shut off service to the majority of the building while serving only occupied portions.	9/26/06 meeting discussion

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Scott Hixon, DGS/BPM
Daniel Burgoyne, DGS

FROM: Erik Kolderup
Derek Kmicikiewicz

DATE: September 28, 2006 (revised 10/10/06)

SUBJECT: Caltrans District 3 Office – Commissioning Design Review

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6.	Consideration should be given to separate evaporative cooling of makeup air for the kitchen rather than using mechanically cooled air. The RFP states, "Provide for energy-efficient makeup air system" (24.C.6.f.3). However, if evaporative cooling is used for makeup air, it must be confirmed that adequate comfort conditions can be maintained in the kitchen. It is possible that mechanical cooling may be required to supplement evaporative cooling. There are good guidelines on kitchen ventilation available at www.energydesignresources.com/resource/184/, and www.fishnick.com/ckv/designguide.	Submittal D30, p. 2 of 3, "Café Systems"
7.	Minor detail: statement regarding 100,000 hour lamp life appears to be a mistake.	Sustainable Design, p. 4 of 11
8.	Carbon Dioxide Sensing. The submittal states that CO_2 will be sensed at the return of each air handling unit to control outside air. Please note that sensing within the individual spaces is likely necessary to achieve LEED credits and meet Title 24 requirements for high occupancy spaces.	Sustainable Design, p. 6 of 11
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Deleted: serving with the same conditioned air as the dining area

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11.	The submittal describes a proposed goal of 20% energy savings below Title 24-2005. However, the RFP lists a goal of 25%, and the contractor's proposal included a LEED scorecard indicating 5 credits for energy performance, equal to at least 24.5% savings. The concern here is that there could be a "slippage" of the performance target. If the contractor proposes to change the goal, the change should be highlighted and the reasons for the change should be made clear to the State.	Sustainable Design, p. 10 of 11
12.	Some of the measures listed as "further enhancements (to baseline designs) were also listed in the RFP Design Guidelines (24.C.8) as design features for the contractor to consider in meeting the 25% energy savings goal. Therefore, it seems that they should not necessarily be presented as additional cost items if they are necessary to meet the overall performance goal listed in the RFP. This comment applies to daylight harvesting system, reduced friction loss in ducts and pipes, and pre-cooling outside air.	Sustainable Design, p. 11 of 11
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TO: Richard Myren, DGS/PMB

CC: Ken Adams & Mark Case, Jacobs
Norman Bourassa, California Energy Commission
Daniel Burgoyne, DGS

FROM: Erik Kolderup
Derek Kmicikiewicz

DATE: December 11, 2006

SUBJECT: Caltrans District 3 Office – Commissioning Design Review - Electrical

This memo lists AEC's comments based on the following:

- Turner's 11/30/06 "systems confirmation" submittal for electrical systems, consisting of plans and specifications.

Please note that this review focuses on energy performance and is not comprehensive for compliance with the overall Design Guidelines and Performance Criteria.

In general, the lighting design appears to meet the Design Guidelines and Performance Criteria. Elements such as details of lighting controls and lighting circuiting are not yet included and will be reviewed at the CD phase. Specfic comments and recommendations are listed below.

	Comment	Reference	Recommended Status
1.	References in the specifications to interior daylighting control have been deleted in the submitted specifications when compared to Performance Criteria. This deletion appears to be in conflict with the Design Guidelines, Section 3-26 that state: "Areas located at the perimeter of the building shall be provided with day lighting controls. Controls shall interface with lighting circuiting to provide uniform lighting levels throughout the day lit area." (Section E.9.) and "Interior lighting shall be controlled via a low voltage lighting control system and occupancy sensors. Where applicable, the building will include interior photo sensors inter-tied to the lighting fixtures for day-lighting control." (Section F.2.)	Spec 260923 Spec 260926	Respond during CDs
2.	Recommend use of "second generation" T-8 lamps for most fixtures, typically with 3100 lumen output for 4-ft lamp, and high efficiency electronic ballasts with ballast factor selected to minimize input power while providing adequate illumination. Lamp and ballast cost is slightly higher than standard lamps and ballasts, but significant energy savings are provided.	E01	For information only
3.	Not indicated what lamp type is proposed for fixture F21 in the "canyon". Fluorescent lamps have the advantage of instant on/off and are better suited to daylighting control than HID type lamps, which require a time delay for restrike.	EL2.4	For information only

4.	Lighting control details are not yet included on the plan, which is ok at this stage. For CDs, please note the following control requirements in the Design Guideline Section 3-26, Subsections E and F. "Occupancy sensing devices shall be utilized to interface with lighting controls (in addition to mandated California Title 24 requirements) to provide maximum energy efficiency. Occupancy sensor spacing shall be in accordance with the manufacturer's recommendations and shall provide full coverage of the area controlled. Non-occupied open office lighting should be stepped down to about 1/3 rather than revert to a full off condition during normal operating hours." "Enclosed stairs shall include occupancy sensor controls to reduce the lighting within the stair (by a minimum of 50%) when it is not occupied." "Toilet rooms shall include occupancy sensor controls to turn off all the non-night light fixtures when the room is not occupied. Occupancy sensor time delays shall be set at a minimum of 20 minutes." "A centralized lighting control panel with satellite panels in each electrical room shall be provided to control the lights and to provide a time based automatic shut-off system."		For information only
5.	Please verify that Emergency/Stand-by Generator and automatic transfer switch sizing meet the requirements from the design guidelines, Section 3-26, subsection C.2.. "The generator and ATS's shall be sized at no less than 125% of the total connected load plus 25% future / spare capacity." It is not clear that the current calculations include the 25% future capacity, i.e. 125% *125% = 156% of connected load.	E02	Respond during CDs

ARCHITECTURAL ENERGY
CORPORATION
Integrated Engineered Solutions

Memorandum

To: Toby Leitch, Turner Construction

From: Derek Kmicikiewicz, P.E.
Alex Ho, Staff Engineer, Commissioning

Date: May 14th, 2008

Subject: Caltrans District 3 Headquarters, Marysville 95% CD Design Review

One of the responsibilities under AEC's commissioning contract is to perform a review of the design documents. The purpose of the review is to identify building system design issues and potential operation and maintenance issues that should be addressed during the construction documents phase.

This review is based on the following documents:

- 95% CD Drawing Set, dated May 14, 2007

We understand that some of the issues listed below may have already been addressed by the design team or are impractical due to specific project constraints. Some other issues would probably have been addressed going forward in the construction documents phase. Therefore, none of the comments on this list is intended to be a criticism of the current design.

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Mechanical System

	Comment	Reference
Condenser water system	Both tower (primary) and building (secondary) condenser water loops consist of two large CW pumps and one small night-load CW pump. All CW pumps are on VFD drives. Only rooftop unit AC-4 was equipped with 3-way control valve and the circuit setter on the bypass pipe was set to 30 GPM water flow. All 2-way condenser loop water control valves provide ON/OFF operation only, this 3-way valve will maintain minimum water flow when all 2-way valves are closed. In order to maintain proper operation of VFD drive and provide optimum cooling conditions for pump motors the minimum output frequency shall not be lower than 20 Hz. When small CW pump (460 GPM) is running at 33% of the design speed (i.e. at 20 Hz), condenser water flow will be reduced to about 150 GPM (approx. 30% of the design flow). Therefore, the minimum water flow for the building condenser loop shall be 150 GPM. We recommend the circuit setter mentioned above shall have flow adjustment capability from 0 GPM to 150 GPM for system tune up by the TAB contractor.	AC0.2, AC6.1
Heating hot water system	3-way HHW control valves are located at each VAV reheat coil at the end of the loop on each floor. This is a good practice as it allows a minimum HHW flow and maintains constant supply HHW temp throughout the building.	AC0.3
Package A/C units (Heat pumps)	Condenser water control valves shall be interlocked with water source heat pump compressors. When a call for heating/cooling is initiated each heat pump calls for condenser water supply circuit to open and BAS opens a corresponding CW 2-way control valve. When water flow is confirmed by HP the flow switch a reversing valve(s) will be set to heating/cooling position and a compressor will be turned ‘ON’. Some heat pumps are equipped with secondary condensate drain pan. A moisture sensing switch inside the secondary drain pan shall shut off the unit when a leak is detected.	AC6.1

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Dual mode of operation CRAC units	CRAC system piping diagram on AC6.2 indicates that these units could operate using either the building condenser water loop (cooling towers) or roof mounted dry coolers. Switching between the two modes of operation is accomplished thru 3-way connection both circuits. Because dry coolers and circuiting pumps are normally wired to and controlled directly by CRAC units, dry cooler sequence of operation (canned program?) shall be altered to accommodate dual mode of operation. BAS system shall control CRAC unit operation. We recommend that Liebert, the unit manufacturer, demonstrate how the CRAC units would operate in these conditions with different piping configurations. As indicated by CRAC unit SOO dry coolers are designed to serve as a back up to building CD loop and will be enabled only if the building CD loop fails. We recommend implementing a runtime schedule – dry cooler shall be turned ON periodically for at least 8 hours a week. This would allow for regular switchovers between both CD water systems and would provide a reasonable guarantee that the dry cooler system will start when called by the SOO.	AC6.2, AC7.3

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142 Minna Street, 2nd Floor
San Francisco, California 94105
TEL (415) 957-1977
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TO: Richard Myren, DGS

FROM: Erik Kolderup

DATE: April 13, 2007

SUBJECT: Caltrans District 3 Building Replacement – Submittal Review

The following submittal was delivered to AEC "for information only". Rosie Rodriguez of Jacobs noted that we should route any comment through you.

Submittal – Construction Phase Sub 0001-018113-0 LEED Scorecard, April 5, 2007

Energy & atmosphere credit 1 (EAc1) is shown as earning 2 points, which corresponds to between 14 and 17.5 percent energy cost savings compared to Title 24-2005. As noted in AEC's review of the HVAC systems confirmation submittal, the energy savings goal listed in the performance criteria is 25 percent. While there appear to be enough credits to achieve LEED-NC 2.2 Silver certification without increasing the energy savings percentage, the lower savings level will have a long term operating cost impact on the State.

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SUBMITTAL REVIEW SHEET

PROJECT NAME: Caltrans District 3 HQ, Marysville

PROJECT NUMBER: 05-023

REVIEW DATE: 5/12/2008

SUBMITTAL ITEM	CONTRACTOR	PAGE OR SECTION	NOTE #	ACTION CODE	REVIEW ORG.
HVAC Equipment Submittals - AHUs	acco	Tab 1	1	B	
HVAC Equipment Submittals - HPs	acco	Tab 2	2	B	
HVAC Equipment Submittals - CRAC units	acco	Tab 3	3	B	
HVAC Equipment Submittals - MUA	acco	Tab 4	-	A	
HVAC Equipment Submittals - Boilers	acco	Tab 5	-	A	
HVAC Equipment Submittals - CT	acco	Tab 6	-	A	
HVAC Equipment Submittals - HX	acco	Tab 7	-	A	
HVAC Equipment Submittals - CWPs	acco	Tab 9	-	A	
HVAC Equipment Submittals - HHWPs	acco	Tab 10	-	A	
HVAC Equipment Submittals - EFs	acco	Tab 12	-	A	
HVAC Equipment Submittals - VAV Boxes	acco	Tab 14	-	A	
BAS/EMS Submittals	Siemens	Tab 5	4, 5, 6 & 7	B	
Lighting Control System Submittal	Helix Electric		8	B	

ACTION CODES: A -NO EXCEPTION TAKEN; B -MAKE CORRECTIONS AS NOTED, RESUBMITTAL NOT REQUIRED; C -MAKE CORRECTIONS AS NOTED, RESUBMITTAL REQUIRED; D -MAKE CORRECTIONS AS NOTED, PROVIDE ADDENDUM SUBMITTAL; E -REJECTED; F -NOT REVIEWED.

NOTE #	NOTE
1	Petra rooftop units AC-1, 2, 3, 4 & 5 are equipped with manufacturer supplied onboard controllers. In current configuration BAS enables/disables units 'ON' & 'OFF' thru BACnet interface. The units run by themselves according to programmed sequences - occupied htg/clng mode, unoccupied mode, manual override. BAS reports only their operating status. The other modes of operation - morning warmup & cooldown - described in SOO on drawing AC7.3, part of 100% CD set, cannot be fully implemented w/o BAS having higher control authority over the units. We recommend higher level of integration with BAS in order to implement SOO listed on the contract drawings.
2	It appears that ClimateMaster GC and GL series heat pump units have heating capability not required for this type of spaces - electrical rooms. Reversing valves shown on a typical heat pump wiring diagram indicate a solenoid type valves set to 'fail' in heating mode. This means that a valve failure would automatically make heat pumps go into heating mode and space temperature would begin to rise and could go higher than the cooling setpoint. This might cause over-heating of electrical rooms and may damage equipment inside. We recommend removing these valves prior to unit delivery.
3	Dehumidifying features are not available on the CRAC unit specified. Units not equipped with re-heating sections (electrical, gas or hot gas bypass type). Please explain how it is possible for the CRAC unit to maintain precise control of, both temperature and humidity, within the server/computer room without reheat features of any kind, or that it is not required (??).
4	Diagram on Siemens' drawing system #100, shows Siemens BAS to be LonTalk based whereas Petra rooftop units use BACnet and CRAC units & Lighting Control System use Modbus. All three (3) systems need to be interfaced with BAS in order to facilitate BAS control over RTUs, CRACs and lighting control system.

NOTE #	NOTE
5	Heat Pump control schematic diagram on drawing #403 does not provide compressor status. BAS needs compressor status to open/close condenser loop control valve whenever the heat pump is operating in heating/cooling mode. Please explain how in current configuration a heat pump condenser loop control valve is interlocked with a compressor. Having condenser water loop valves closed when compressors are not running allows condenser water pump VFDs to dial back due to increased condenser water loop DP. This creates energy savings as pumps draw fewer kWs.
6	Comparing heat pump control schematic diagrams on drawing #403 with that on drawing #404 (units w/ two compressors) we note that common wiring for fan and compressor controls is missing. Please make necessary corrections.
7	On drawings #702, 703 & 704, SOO indicates the makeup air unit, space heaters and water treatment system are all controlled by BAS but the corresponding control schematic diagrams are missing. Power grid status and/or generator status sensor shall be in place in order to implement an emergency power mode of operation.
8	SOO for lighting control system not found. Please provide information about the lighting and lighting control system as well as sequence of operation and control system programming.

REVIEWER: Alex Ho

DATE: May 12, 2008

Refrigerant metering shall be accomplished by capillary tube assembly. Reversing valve shall be four-way solenoid activated refrigerant valve, which shall default to heating mode should the solenoid fail to function. If the unit's reversing valve solenoid defaults to cooling mode, a separate low temperature thermostat must be provided to prevent over-cooling an already cold room.

Drain Pan:
The drain pan shall be constructed of galvanized steel and have a powder coat paint application to further inhibit corrosion. This corrosion protection system shall meet the stringent 1000 hour salt spray test per ASTM B117. If plastic type material is used, it must be HDPE (High Density Polyethylene) to avoid thermal cycling shock stress failure over the lifetime of the unit. Stainless Steel materials are also acceptable. Drain pan shall be fully insulated. Drain outlet shall be located at pan as to allow complete and unobstructed drainage of condensate. Drain outlet for horizontal units shall be connected from pan directly to IPT fitting. ***No hidden internal tubing extensions from pan outlet extending to unit casing (that can create drainage problems) will be accepted.*** The unit as standard will be supplied with solid-state electronic condensate overflow protection. ***Mechanical float switches will NOT be accepted.***

Vertical units shall be furnished with a PVC slip condensate drain connection and an internal factory installed condensate trap. ***If units without an internal trap are used, the contractor is responsible for any extra costs to field install these provisions, and/or the extra costs for his sub-contractor to install these provisions.***

Electrical:
A control box shall be located within the unit compressor compartment and shall contain a 50VA transformer, 24 volt activated, 2 or 3 pole compressor contactor, terminal block for thermostat wiring and solid-state controller for complete unit operation. Reversing valve and fan motor wiring shall be routed through this electronic controller. Units shall be name-plated for use with time delay fuses or HACR circuit breakers. Unit controls shall be 24 Volt and provide heating or cooling as required by the remote thermostat / sensor.

Solid State Control System (CXM):
Units shall have a solid-state control system. ***Units utilizing electro-mechanical control shall not be acceptable.*** The control system microprocessor board shall be specifically designed to protect against building electrical system noise contamination, EMI, and RFI interference. The control system shall interface with a heat pump type thermostat. The control system shall have the following features:

a. Anti-short cycle time delay on compressor operation.
b. Random start on power up mode.
c. Low voltage protection.
d. High voltage protection.
e. Unit shutdown on high or low refrigerant pressures.
f. Unit shutdown on low water temperature.
g. Condensate overflow electronic protection.
h. Option to reset unit at thermostat or disconnect.
i. Automatic intelligent reset. Unit shall automatically reset the unit 5 minutes after trip if the fault has cleared. If a fault occurs 3 times sequentially without thermostat meeting temperature, then lockout requiring manual reset will occur.
j. Ability to defeat time delays for servicing.
k. Light emitting diode (LED) on circuit board to indicate high pressure, low pressure, low voltage, high voltage, low water/air temperature cut-out, condensate overflow, and control voltage status.
l. The low-pressure switch shall not be monitored for the first 120 seconds after a compressor start command to prevent nuisance safety trips.
m. 24V output to cycle a motorized water valve or other device with compressor contactor.
n. Unit Performance Sentinel (UPS). The UPS warns when the heat pump is running inefficiently.
o. Water coil low temperature sensing (selectable for water or anti-freeze).

NOTE: Units not providing the 7 safety protections of anti-short cycle, low voltage, high voltage, high refrigerant pressure, low pressure (loss of charge), water coil low temperature cut-out, and condensate overflow protections will not be accepted.

Option: Enhanced solid state control system (DXM)
This control system features two stage control of cooling and two stage control of heating modes for exacting temperature and dehumidification purposes.

This control system coupled with a multi-stage thermostat will better dehumidify room air by automatically running the heat pump's fan at lower speed on the first stage of cooling thereby implementing low sensible heat ratio cooling. On the need for higher cooling performance the system will activate the second stage of cooling and automatically switch the fan to the higher

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **www.climatemaster.com.**

entering water temperatures from 20° to 110°F (-6.7° to 43.3°C). Reversing valve shall be four-way solenoid activated refrigerant valve, which shall default to heating mode should the solenoid fail to function. If the reversing valve solenoid defaults to cooling mode, an additional low temperature thermostat must be provided to prevent over-cooling an already cold room.

Drain Pan:
The drain pan shall be constructed of galvanized steel and have a powder coat paint application to further inhibit corrosion. This corrosion protection system shall meet the stringent 1000 hour salt spray test per ASTM B117. If plastic type material is used, it must be HDPE (High Density Polyethylene) to avoid thermal cycling shock stress failure over the lifetime of the unit. Stainless Steel materials are also acceptable. Drain pan shall be fully insulated. Drain outlet shall be located at pan as to allow complete and unobstructed drainage of condensate. Drain outlet for shall be connected from pan directly to IPT fitting. ***No hidden internal tubing extensions from pan outlet extending to unit casing (that can create drainage problems) will be accepted.*** The unit as standard will be supplied with solid-state electronic condensate overflow protection. ***Mechanical float switches will NOT be accepted.***

Electrical:
A control box shall be located within the unit compressor compartment and shall contain a 75VA transformer with load side circuit breaker protection, 24 volt activated, 2 or 3 pole compressor contactor, terminal block for thermostat wiring and solid-state controller for complete unit operation. Reversing valve and fan motor wiring shall be routed through this electronic controller. Units shall be name-plated for use with time delay fuses or HACR circuit breakers. Unit controls shall be 24 Volt and provide heating or cooling as required by the remote thermostat / sensor. Two compressor units shall have a solid-state time delay relay and random start to prevent both compressors from starting simultaneously.

Solid State Control System (CXM):
Units shall have a solid-state control system. ***Units utilizing electro-mechanical control shall not be acceptable.*** The control system microprocessor board shall be specifically designed to protect against building electrical system noise contamination, EMI, and RFI interference. The control system shall interface with a heat pump type thermostat. The control system shall have the following features:

a. Anti-short cycle time delay on compressor operation.
b. Random start on power up mode.
c. Low voltage protection.
d. High voltage protection.
e. Unit shutdown on high or low refrigerant pressures.
f. Unit shutdown on low water temperature.
g. Condensate overflow electronic protection.
h. Option to reset unit at thermostat or disconnect.
i. Automatic intelligent reset. Unit shall automatically reset the unit 5 minutes after trip if the fault has cleared. If a fault occurs 3 times sequentially without thermostat meeting temperature, then lockout requiring manual reset will occur.
j. Ability to defeat time delays for servicing.
k. Light emitting diode (LED) on circuit board to indicate high pressure, low pressure, low voltage, high voltage, low water/air temperature cut-out, condensate overflow, and control voltage status.
l. The low-pressure switch shall not be monitored for the first 120 seconds after a compressor start command to prevent nuisance safety trips.
m. 24V output to cycle a motorized water valve or other device with compressor contactor.
n. Unit Performance Sentinel (UPS). The UPS warns when the heat pump is running inefficiently.
o. Water coil low temperature sensing (selectable for water or anti-freeze).
p. Air coil low temperature sensing.

NOTE: Units not providing the 8 safety protections of anti-short cycle, low voltage, high voltage, high refrigerant pressure, low pressure (loss of charge), air coil low temperature cut-out, water coil low temperature cut-out, and condensate overflow protections will not be accepted.

Option: Enhanced solid state control system (DXM)
This control system features two stage control of cooling and two stage control of heating modes for exacting temperature and dehumidification purposes. Control shall have all of the above mentioned features of the CXM control system along with the following expanded features:
a. Removable thermostat connector.
b. Night setback control.
c. Random start on return from night setback.
d. Minimized reversing valve operation (Unit control logic shall only switch the reversing valve when cooling is demanded for the first time. The reversing valve shall be held in this position until the first call for heating, ensuring quiet operation and increased valve life.).

ClimateMaster works continually to improve its products. As a result, the design and specifications of each product at the time of order may be changed without notice and may not be as described herein. Please contact ClimateMaster's Customer Service Department at 1-405-745-6000 for specific information on the current design and specifications. Statements and other information contained herein are not express warranties and do not form the basis of any bargain between the parties, but are merely ClimateMaster's opinion or commendation of its products. The latest version of this document is available at **www.climatemaster.com**.

ARCHITECTURAL ENERGY CORPORATION
Integrated Engineered Solutions

ARCHITECTURAL ENERGY CORPORATION
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San Francisco, California 94105
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SUBMITTAL REVIEW SHEET

PROJECT NAME: Caltrans District 3 HQ, Marysville

PROJECT NUMBER: 05-023

REVIEW DATE: 6/2/2008

SUBMITTAL ITEM	CONTRACTOR	PAGE OR SECTION	NOTE #	ACTION CODE	REVIEW ORG.
BAS/EMS Re-submittals	Siemens	Tab 5	1 to 4	B	

ACTION CODES: A -NO EXCEPTION TAKEN; B -MAKE CORRECTIONS AS NOTED, RESUBMITTAL NOT REQUIRED; C -MAKE CORRECTIONS AS NOTED, RESUBMITTAL REQUIRED; D -MAKE CORRECTIONS AS NOTED, PROVIDE ADDENDUM SUBMITTAL; E -REJECTED; F -NOT REVIEWED.

NOTE #	NOTE
1	The Night Cool-down, Night Heating and Night Cooling sequences were not mentioned in the SOO of the Petra rooftop units submittal. Please verify that Petra units are capable of operating in those modes and programmed per what is described in Siemens' SOO.
2	It appeared that the demand control ventilation on CO2 level for rooftop unit AC-5 could not be implemented as the unit was not equipped with an OA flow station. The minimum OA damper position will be adjusted to provide the design CFM thru actual OA flow measurements by the TAB contractor. If demand control ventilation for AC-5 (serving the Cafeteria) is still required, the OA damper shall be overrode and opened to maximum position **thru BAS** when the space CO2 level is above setpoint.
3	As capacities of CW pumps CWP-1, 2 & 3 for cooling tower loop were in match with those of CW pumps CWP-4, 5 & 6 for building loop respectively, staging ON/OFF controls for pumps should be of 3 stages - one small pump for Stage 1, one large pump for Stage 2, and two large pumps for Stage 3. Please amend the staging control for CWP-1, 2 & 3 accordingly.
4	Please explain why heating hot water temperature reset strategy was not implemented for HHW setpoint as indicated in Hot Water System section of SOO.

REVIEWER: Alex Ho

DATE: June 2, 2008

Turner + acmp

Tuesday, June 3, 2008

Mr. John Wood
Architectural Energy Corporation
2540 Frontier Ave, Suite 201, Boulder, CO 80301

RE: Caltrans District 3 Headquarters
820 Chestnut Street, Marysville, CA 95901
Project #: 13042D0
Submittal Review

Dear Mr. Wood,

Ref: Submittal Review # 1 dated 5/12/2008 – Responses from ACCO

Note 1: The other modes of operation have been reviewed and can be accomplished using the Bacnet interface. A meeting of coordination was held 11/7/2007 between ACCO, Siemens, and the Petra representative. The modes of operations were reviewed and the points required to implement the Sequence were identified. Please refer to the revised Sequence of Operations dated 5/19/2008.

Note 2: ACCO will 'hard wire' the reversing valves to prevent the valve switching over to heating mode.

Note 3: The evaporator coil acts as s humidifier, and the low latent load, in the space does not justify an additional dehumidifier. The onboard thermostat and humidistat will control temperature and humidity of the computer room.

Note 4: Siemens drawing 100 does not show Siemens BAS with LonTalk. On Siemens drawing 100, controller MEC-5 will be provided with Bacnet MSTP driver to interface to the factory installed Petra unit controls utilizing ALC controls. Controller MEC-5 will be provided with a Modbus driver to interface to CRAC and Lighting Systems that have Modbus interfaces.

Note 5: The Heat Pump units do not have condenser valves. These valves were deleted to provide a minimum flow capability for the CW system.

Note 6: Corrections have been addressed in the revised submittal.

Note 7: The Makeup air unit is controlled by the Siemens BAS. The schematic drawing was accidentally missing from the original submittal and is included on DWG 410 of the revised submittal. The Infrared heater (space heater) is controlled by a line-voltage thermostat and does

not have BAS control. The Water Treatment System does not have BAS controls - this issue requires a response from ACCO. The point for status of "Normal" electrical power is shown on DWG 300 of revised submittal.

Note 8: Lighting Control Manual submitted via E-mail on 5/22/08

Sincerely,

Rinku Kini
Engineer

cc: File, D German, Jacobs, Glumac

Turner + acmp

Thursday, June 18, 2008

Mr. John Wood
Architectural Energy Corporation
2540 Frontier Ave, Suite 201, Boulder, CO 80301

RE: Caltrans District 3 Headquarters
820 Chestnut Street, Marysville, CA 95901
Project #: 13042D0
BAS Submittal Review

Dear Mr. Wood,

Ref: BAS Submittal Review # 2 dated 6/02/2008 – Responses from ACCO

#1 The Night cool-down, Night heating, and Night cooling sequences were not mentioned in the SOO of the Petra rooftop units submittal. Please verify that Petra units are capable of operating in those modes and programmed per what is described in Siemen's SOO.

#1 Response: The Petra units have 3 modes of operation built-in to the ALC controller: occupied, unoccupied, and morning warm-up. Night cool-down, night heating, and night cooling modes are not available as standalone modes. The additional 3 modes - night cool-down, night heating, and night cooling – will be implemented by Siemens as hybrid modes. Siemens will combine the Petra modes with specific Bacnet network commands to achieve the desired mode, for example, compressor lockout for purging cycles, economizer enable/disable for purging cycles, and temperature setpoints.

#2 It appeared that the demand control ventilation on CO2 level for rooftop unit AC-5 could not be implemented as the unit was not equipped with an OA flow station. The minimum OA damper position will be adjusted to provide the design CFM thru actual OA flow measurements by the TAB contractor. If demand control ventilation for AC-5 (serving the Cafeteria) is still required, the OA damper shall be overrode and opened to maximum position thru the BAS when the space CO2 level is above setpoint.

#2 Response: The Siemens control system will override the O.A. minimum position to increase O.A. demand

#3 As capacities of CW pumps CWP-1, 2, & 3 for cooling tower loop were in match with those of CW pumps CWP-4, 5, & 6 for building loop respectively, staging ON/OFF control for pumps

should be of three stages - one small pump for stage 1, one large pump for Stage 2, and two large pumps for Stage 3. Please amend the staging control for CWP-1, 2, & 3.

#3 Response: ACCO and Siemens prefers the current sequencing of the pumps. With the complexity of the CW system, it may be
better to sit down and have a meeting, and go over the staging of the CW system.

#4 Please explain why heating hot water temperature reset strategy was not implemented for HHW setpoint as indicated in Hot Water System section of SOO.

#4 Response: Title 24 does not require heating hot water temperature reset for variable flow systems, per section 144(j)1.

Sincerely,

Rinku Kini
Engineer

cc: File, D German, Jacobs, Glumac

5.0 Memos, Meeting Notes and Relevant Correspondence

This section contains selected documents produced during the course of commissioning by members of commissioning team. They are attached here to highlight important issues encountered during commissioning process and to illustrate a resolution path taken by the commissioning team.

Turner + acmp

Transmittal Cover Sheet

Detailed, Grouped by Each Transmittal Number

Caltrans District 3 Headquarters
820 Chestnut Street
Marysville, Ca 95901

Project # 13042D0
Tel: 530-740-4640 Fax: 530-740-7705

Turner Construction

Date: 7/8/2008 Transmittal No: 0570

Transmitted To:	Transmitted By:
Mark Chase Jacobs 820 Chestnut Street Marysville, CA 95901 Tel: 530-740-4671 ext. 214 Fax:	Rinku Kini Turner Construction 820 Chestnut Street Marysville, CA 95901 Tel: 530-740-4644 Fax: 530-740-7705

☑ **Acknowledgement Required**

Package Transmitted For:	Delivered Via:	Tracking Number:
As Requested	Hand	

Item#	Qty	Item	Reference	Description	Notes	Status
001	1.00	Documents	Siemens Checklists for AEC			

Co.	Company Name	Contact Name	Copies	Notes

Remarks:

COMMISSIONING - Siemens Checklists

We approved on the format of the point-to-point checkout sheets. Please submit the filled-out sheets of equipment of control system for our review.

Alex Ho 7/18/08

RZKini

Signature

7/8/08

Signed Date

Turner + acmp

Commissioning Meeting

Detailed, Grouped by Topic

Project #13042D0 - Caltrans District 3 Headquarters
820 Chestnut Street
Marysville, Ca 95901

Turner Construction
Tel: 530-740-4640
Fax: 530-740-7705

Meeting #2

Date	Start	End	Next Meeting	Next Time	Prepared By	Company
5/21/2008	10:00 AM				Rinku Kini	Turner Construction

Purpose	Location	General Notes
Building Commissioning Meeting #2	Jobsite	

Attended By	Non-Attendees
Alex Ho - Architectural Energy Corporation	
Derek Kmicikiewicz - Architectural Energy Corporation	
Gary Elnan - Siemens Building Technologies, Landis Division	
Justin Heinrich - Turner Construction	
Mark Chase - Jacobs	
Mike Price - Helix Electric, Inc.	
Mike Savage - ACCO Engineered Systems	
Mitchell Dec - Glumac International	
Richard Myren - State of California Department of General Services	
Rick Langley - State of California Department of General Services	
Rinku Kini - Turner Construction	
Russ Derickson - Architectural Energy Corporation	
Toby Leitch - Turner Construction	
Wes Hubbart - State of California Department of General Services	

General Business

Item	Description	Resp	Status	Due Date	Compl'd	Drop
B.O.D.						
001-005	12/7/06- The question was raised whether a basis of design document would be required above and beyond the Part 3 of the RFP, combined with the systems submittal narratives and contract. AEC will review whether what documentation exists and will be created is satisfactory to meet the "basis of design" requirement (deliverable).	DGS	Passed			No
002-011	5/23/08 A revised BOD required from Helix and ACCO to update the initial OPR	ACMP/Helix/ACCO	Open			No
Commissioning						
002-008	5/23/08 AEC to receive a schedule of all start-up of equipments from Turner	Turner/Helix/ACCO	Open			No
Design Review						
001-007	12/7/06- DGS suggested that AEC may want to do an unofficial "over the shoulder" at 50% CD, directly with design build contractors and engineers. Turner was	All	Closed			No

Item	Description	Resp	Status	Due Date	Compl'd	Drop
	open to this suggestion.					
002-001	5/23/2008 - Derek w/AEC went over their comments and concerns from the submittals and 95% design review with ACCO. ACCO was going to type out these back checks and send it to Turner.	ACCO	Open			No
002-010	5/23/08 Helix to send information on the photo cells at the canyon	Helix	Open			No
Enhanced Commissioning						
001-006	12/7/06- Question was asked by Turner- what documentation is required by USGB to satisfy that the enhanced commissioning point criteria has been met.	Glumac	Closed			No
002-002	5/23/2008 We discussed the Enhanced Commissioning LEED point, but we needed design review comments from AEC to be able to work on that point. Russ w/AEC will send us some information for this LEED point.	AEC	Open			No
PFT & FPT						
002-003	5/23/2008 Turner to send AEC, sample HVAC Prefunctional checklist for their review and develop it once AEC approves of the format.	Turner	Sent			No
002-004	5/23/2008 AEC to send a sample Lighting Control Prefunctional Checklist for Helix's use.	AEC	Open			No
Photo Voltaics						
001-003	12/7/06- Discussion of including PV solar panels future accommodation was discussed. Turner ACMP has not considered this in the design. If DGS is interested, a request for proposal should be issued.	DGS	Open			No
002-009	5/23/08 Turner/ACMP designing a PV system as a proposal to DGS	ACMP	Open			No
Submittals						
002-005	5/23/08 Turner to receive from ACCO and send out all required O&Ms and Sequence of Operation to AEC.	Turner	Open			No
002-006	5/23/08 Turner to receive from Helix and send out all required O&Ms and Sequence of Operation to AEC	Helix	Open			No
Title 24						
002-007	5/23/08 Turner to receive from Helix and send out Title 24 Acceptance forms to AEC	Helix/Turner	Open			No

Cc:	Company Name	Contact Name	Copies	Fax Number	Notes
	AC Martin Partners, Inc.	Carey McLeod	1	213-614-6002	
	Jacobs	Ken Adams	1		

The minutes written above represent our understanding of significant items discussed in the meeting. These minutes shall stand as the correct and complete record of the meeting unless corrections, discrepancies, or additional items are brought to the attention of the writer at or before the next meeting.

Prepared By: _____ Date: 5/28/08

Commissioning Meeting # 2 May 21, 2008

NAME	COMPANY	E-MAIL	PHONE #
Scott Brehmer	NABCO	ScottB@NABCO.BIZ	9168257833
Roy Gale	AirTreatment	rgale@airTreatment.com	916-362-3419
Rick Langley	DGS	Richard.Langley@dgs.ca.gov	916-825-0700
Mitchell Dec	Glumac	mdec@glumac.com	503-345-6283
Rinku Kini	Turner	rkini@tcco.com	530-740-4644
Derek Kmicikiewicz	AEC	dKmicikiewicz@archenergy.com	
Alex Ho	AEC	aho@archenergy.com	(415) 957 1977
Russ Derickson	AEC	rderickson@archenergy.com	303-444-4149
Mike Savage	ACCO	MSAVAGE@ACCOES.com	916 852-5050
Mike Dabbert	ACCO	mdabbert@accoes.com	916 852-5050
Kevin Kiley	ACCO	KKILEY@ACCO	9168525050
Gary Elnan	Siemens	Gary.Elnan@Siemens.com	916-553-6932
Wes Hubbart	DGS	whubbart@dgs.ca.gov	916.869.1911
Justin Heinrich	TCCO	jheinrich@tcco.com	916-215-7167
Mark Chase	Jacobs	MARK.CHASE@JACOBS.com	916-437-9432
Mike Price	Helix Elect.	mprice@helixelectric.com	(858)405-5164
Richard Myren	DGS	RICHARD.MYREN@DGS.CA.GOV	916-708-4124
Toby Leitch	Turner	tleitch@tcco.com	530-740-4646

AGENDA
5/1/08 Commissioning of Caltrans Marysville Project

Part 1: Specifics for Commissioning (Cx) and LEED certification:

1. Brief update on project status from Turner/Jacobs.
2. AEC role and Cx activities in the coming months. (John Wood, AEC)
3. Update on submittals for CxA (John Wood) review and preparation of pre-functional checklists (PFCs). Rinku/Turner? How to improve this process in the future?
4. Clarification of when/who writes/reviews PFCs (John Wood and/or contractor). What do the contractors prefer?
5. When/who writes/reviews functional performance tests (FPTs), (John Wood and/or T24 contractor)?
6. How to incorporate the T24 acceptance tests (maybe as a line item in FPT?)
7. LEED/Glumac status and questions:

- What design reviews are available or lacking to get LEED EACr3? (Comment from John Wood: One current design review, with responses from Design professionals, might suffice for a 95% review, and consider previous reviews "DD", even though they have slightly more of an SD appearance).
- How much more do we expect the design to evolve? Bulletin 10?
- Where are spec sections 230800, 019113? Do they exist?
- Was an electrical narrative prepared?

Part 2: Marysville project relative to integration DGS into the Cx process (general discussion):

1. How to incorporate DGS into the construction phase process (i.e. attend FPTs).
2. Communication protocol: AEC recommends that the owner (or Jacobs) need not be involved to take documents that are already available from the contractor and send them on to us.
3. Flow chart for design-build process relative to Cx activities.

GLUMAC
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MEETING MINUTES

February 12, 2007

To: Carey Mcleod
AC Martin Partners

From: Erik Ring

rfc:
cc:

Project: CalTrans District 3 Headquarters
Marysville, CA

Mail Original "

Project #: 906100
Subject: LEED-NC Certification Working Session

Meeting Date/Time: **Friday 2/9/07**
8:00 am to 3:00 pm

Meeting Location: CalTrans Marysville Job Site

DISTRIBUTION: *(persons shown in* **bold** *were present)*

Name	Firm	Name	Firm
Steve Schultz	Turner	**David Anderson**	**ACCO**
Abou Idrissi	**Turner**	J Blake	Helix
Doug Gearman	**Turner**	I Altman	Helix
Toby Leitch	**Turner**	**Michael Levitt**	**LPG Engineering**
William Northrup	Turner	Erik Kolderup	AEC
Arlen Arnold	**Turner**	**Erik Ring**	**Glumac**
David Freedman	**ACMP**	Steve Straus	Glumac
Carey McLeod	ACMP	**Reid Appel**	**Glumac**
George vanGilluwe	ACMP	Michael Savage	ACCO
		Jon Pierce	ACCO
		Mike Price	**Helix**
		Jackie Sillman	**Yuba Sutter Disposal**

Item #	Time	Action Req'd	Due Date	Issues/Actions
1	8:00 am	Turner ACMP Glumac		**Project & LEED Status Update** LEED Status revised to reflect: 4 7 prerequisites 4 38 Targeted points (Silver is 33 to 38 points) 4 3 uncertain points 4 28 unobtainable points Updated LEED scorecard is attached. Turner to review and comment on draft 'LEED Construction Manual' provided by Glumac. Once finalized this will be provided to all sub-contractors.

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Item #	Time	Action Req'd	Due Date	Issues/Actions
				Uncertain LEED points are: 4 **SSc7.1, Heat Island Effect, Non-Roof** - Can parking shading trees be contract-grown and/or increased to achieve 50% shading in 5-years? 4 **SSc8 Light Pollution Reduction** – Glumac, Helix, and LPG to evaluate site lighting design relative to this credit. 4 **EAc6 Green Power** - Can be purchased if necessary by DGS. Per Caltrans and DGS third-party financed photovoltaic systems will not be added to the project.
2	8:30 am	Turner ACMP Glumac		**Site Management LEED Issues** 4 **Erosion Control (SSp1)** Project SWPP will meet requirements. 4 **Construction Waste Mgmt (MRc2)** Yuba-Sutter disposal will provide multiple bins along with waste hauling reports indicating recycling rate for construction waste. Turner, demo contractor, and Yuba-Sutter Disposal to coordinate to insure that demolition waste (concrete and asphalt) is recycled at highest extent feasible, and that waste quantities are recorded and tracked Glumac to research drywall/gypsum recycling opportunities. 4 **Construction IAQ Mgmt (EQc3, EQc4)** Turner to manage and document construction IAQ plan and low-emitting materials as outlines in LEED Construction Manual. Turner to include building flush-out

Item #	Time	Action Req'd	Due Date	Issues/Actions
				procedures in master construction schedule with details of flush-out procedures to be developed later.
3	9:30 am	Turner ACMP Glumac		**Materials Sourcing Issues** 4 **Recycled Content (MRc4)** Turner to identify and track material values for all scheduled items as the job is bought out. Recycled content of major building materials (pre-cast, cast in place, asphalt, storefront system, interior walls) to be optimized. Unlikely to include any flyash or other recycled content admixture in pre-cast but can be used in cast-in-place concrete. Rebar will include significant recycled content. 4 **Local/Regional Materials (MRc5)** Concrete, asphalt, landscaping materials should make this credit readily achievable. 4 **FSC Certified Wood (MRc7)** Turner to identify cost impact of FSC certified wood interior doors and architectural woodwork when buying out these trades.
4	11:00 am	Turner ACMP Glumac ACCO Helix LPG AEC		**Working Lunch**
5	Noon	Turner ACMP Glumac ACCO Helix LPG AEC		**MEP LEED Issues** 4 **Site Lighting (SSc8)** Glumac, Helix, and LPG to evaluate site lighting design relative to this credit 4 **Plumbing Fixtures (WEc3)** ACCO to inquire whether auto flush fixtures (as indicated in the project RFP) can be

Item #	Time	Action Req'd	Due Date	Issues/Actions
				substituted with manual, dual-flush flushometers. ACCO to specify and install Zurn 1/8 gallon urinals, 0.5 gpm lavatories, 1.6 gpm showerheads. 4 **Commissioning (EAp1, EAc3)** 4 **Measurement & Verification (EAc5)** M&V credit will not be pursued for this project. 4 **Ventilation Rate (EQp1, EQc1, EQc2)** ACCO to prepare ventilation rate calculations to determine where to set minimum ventilation rates for units and to indicate compliance with EQp1 and EQc2. No additional cooling or heating capacity is required. ACCO to specify and install CO2 monitors and outdoor airflow monitors consistent with EAp1. 4 **Construction IAQ Mgmt (Recap)** 4 **Indoor Pollutant Source Control (EQc5)** Project as designed complies with this credit. 4 **Thermal Comfort (EQc7)** Project as designed complies with this credit.
6	1:30 pm	Turner ACMP Glumac		**Design Phase LEED Submittals** Glumac to coordinate and manage the design-phase LEED submittals, with assistance from Turner, ACMP, and the design team, over the next two months. 4 Site Selection (SSc1) 4 Development Density (SSc2) 4 Alternative Transportation

Item #	Time	Action Req'd	Due Date	Issues/Actions
				(SSc4.1, SSc4.2, SSc4.3, SSc4.4) 4 Landscaping (WEc1.1) 4 Water Use (WEc3) 4 Min. Energy Performance (EAp2) 4 Refrigerants (EAp3) 4 Optimize Energy Performance (EAc1) 4 Recyclables (MRp1) 4 Min IAQ Performance (EQp1) 4 Smoking (EQp2) 4 OSA Monitoring (EQc1) 4 Increased Ventilation (EQc2) 4 Indoor Pollutant Control (EQc5) 4 Lighting Controls (EQc6.1) 4 Thermal Comfort Design (EQc7.1) 4 Thermal Comfort Survey (EQc7.2) 4 Innovation Points (IDc1.1) 4 LEED AP (IDc2)
7	3:00 pm			**Adjourn**

These meeting minutes reflect our understanding of the issues discussed. This will act as the project record unless the sender of these minutes is notified within 3 days of the issue date.

Turner + acmp

Meeting Minutes

Detailed, Grouped by Topic for each Meeting and by 'Old Business' and 'New Business'

Cal Trans District 3 Headquarters
820 Chestnut Street
Marysville, Ca 95901

Project # 13042D0
Tel: 530-740-4640 Fax: 530-740-7705

Turner Construction

Commissioning Meeting 1

Date	Start	End	Next Meeting	Next Time	Prepared By	Company
12/7/2006	10:00 AM		12/7/2006		Steve Schultz	Turner Construction

Purpose	Location	Next Location	General Notes
Building Commissioning Kickoff Meeting	Zig		

Attended By	Non-Attendees
State of California Department of General Services - Richard Myren	
State of California Department of General Services - Burton Shanoff	
AC Martin Partners, Inc. - Carey McLeod	
Turner Construction - Steve Schultz	
Glumac International - Reid Appel	
Jacobs - Mark Chase	
Jacobs - Ken Adams	
State of California Department of General Services - John Brackeen	
State of California Department of General Services - Wes Hubbart	
AEC Management Solutions - Derek Knickieuior	
Glumac International - Eric Ring	
Robinson Mills & Williams - William Finney	
State of California Department of General Services - Lynn Palmer	
State of California Department of General Services - Charley Nelson	
State of California Department of General Services - Jesus Cuevas	
State of California Department of General Services - Norma Bourassa	
State of California Department of General Services - Mike Hakari	

Item	Description	Resp	Status	Due Date	Compl'd	Drop
General Business						
New Business						
001-001	12/7/06- Enhanced commissioning is being provided by Architectural Energy Corporation. This meets the requirements for the LEED point as Turner has included.		Information			Yes
001-002	12/7/06- Part of the LEED 2.2 Enhanced Credit is : -"Conduct a focused review of the design prior to the mid construction documents phase". As AEC has been engaged to review the systems submittals- Turner confirmed that this meets this requirement. - Conduct a focused review of the construction documents when close to completion. As the next submittal to the state, will be completed CD documents, (after systems submittal) this will meet this requirement. - Conduct a selective review of contractor submittals of		Information			Yes

Item	Description	Resp	Status	Due Date	Compl'd	Drop
	commissioned equipment. This project design/build process only includes providing "approved submittals" to DGS. - Discussion then took place how these activities fit in the sequence of the design/build process.					
001-003	12/7/06- Discussion of including PV solar panels future accommodation was discussed. Turner ACMP has not considered this in the design. If DGS is interested, a request for proposal should be issued.	DGS	Open			No
001-004	12/7/06- Discussion of upgrading the HVAC controls systems to achieve Point EAc5. DGS requested a price proposal. Turner to request from ACCO.	ACCO	Open			Yes
001-005	12/7/06- The question was raised whether a basis of design document would be required above and beyond the Part 3 of the RFP, combined with the systems submittal narratives and contract. AEC will review whether what documentation exists and will be created is satisfactory to meet the "basis of design" requirement (deliverable).	DGS	Open			No
001-006	12/7/06- Question was asked by Turner- what documentation is required by USGB to satisfy that the enhanced commissioning point criteria has been met.	Glumac	Open			No
001-007	12/7/06- DGS suggested that AEC may want to do an unofficial "over the shoulder" at 50% CD, directly with design build contractors and engineers. Turner was open to this suggestion.	All	Open			No

Cc:	Company Name	Contact Name	Copies	Notes
	Turner Construction	Toby Leitch	1	
	AC Martin Partners, Inc.	Carey McLeod	1	
	Jacobs	Ken Adams	1	
	Jacobs	Mark Chase	1	
	State of California Department of General Services	Richard Myren	1	

Meeting Minutes

Detailed, Grouped by Each Meeting and by 'Old Business' and 'New Business'

Caltrans District 3 Building Replacement
703 "B" Street
Marysville, CA

Project # W.O.114126
Tel: Fax:

Jacobs Facilities Inc.

Systems Confirmation-HVAC/Plumbing Meeting 3

Date	Start	End	Next Meeting	Next Time	Prepared By	Company
10/12/2006	02:00 PM	05:00 PM			Mark Chase	Jacobs Facilities Inc.

Purpose	Location	Next Location	General Notes
Systems Confirmation Submittal presentation by D-B Contractor for HVAC and Plumbing.	Zig Conference Room 3-318	Zig Conference Room 3-318	Architectural Energy Corporation (AEC) is serving as commissioning authority for this project on behalf of DGS and under contract with the CEC. Per Part 3, Section 7 “Building Commissioning” in the Design Guidelines the commissioning authority performs a design review at several stages: schematic design, design development, 50% construction documents, and 95% construction documents. This memo lists AEC’s comments based on the following: • Turner’s September 21, 2006 “systems confirmation” submittal • Presentation by Turner and design/build team members at a September 26, 2006 meeting • (AEC did not receive plans or specs to accompany the submittal narrative) Please note that this review focuses on energy performance and is not comprehensive for compliance with the overall Design Guidelines and Performance Criteria. As a general comment, it appears that the contractor is doing a good job of developing an energy efficient design and performing early energy modeling analysis to inform the design. This review is limited to the information provided to RMW by the Design Builder and is based on the conformance of the information given to the approved schematic design, the design guidelines, conceptual drawings, performance criteria and all addendums included in the Request For Proposal documents. The Design Builder remains responsible for determining the accuracy and completeness of the submittals and for substantiating the performance of equipment or systems. Comments on the systems confirmation submittals during this review do not relieve the Design

Builder of its responsibility to comply with the requirements of the Proposal Documents.
SEE COMMENTS NOTED
ADDITIONAL SUBMITALLS REQUIRED
Review of Systems Confirmation – HVAC/Plumbing of submittal package dated September 21, 2006 includes the following documents:

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Old Business						
Submittal D30, p. 1 of 3, "Core HVAC Systems"						
001-001	The system described in the "Core HVAC Systems" section is reasonable and appropriate.	Mark Chase - JFI	Accepted as Noted			Yes
Submittal D30, p. 1 of 3, "Core HVAC Systems"						
001-002	The submittal describes 35% prefilters and 85% final filters, as called for in the RFP, but the design/build team should consider MERV 13 final filters to help achieve LEED indoor environmental quality credits. 10/12/06 Meeting Comments AEC: Comment provided for information. Possible LEED points.	Arlen Arnold - TCC;	Accepted as Noted			Yes
Submittal D30, p. 2 of 3, "Tenant Distribution System"						
001-003	What is the minimum pressure at which the fabric ducts can operate while still maintaining good air distribution (e.g.	Arlen Arnold - TCC;	Req'd Prior to Approval			No

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	no dumping)? The submittal mentions that they operate at 0.5 in. w.c. If this is higher than a comparable sheet-metal duct, then are the potential savings due to static pressure reset control going to be lower with the fabric ducts? Presumably, the pressure upstream of the VAV boxes should be able to drop as low 0.5 in. during low-load periods with static pressure reset controls, and the pressure in the fabric ducts would be lower. 10/12/06 Meeting Comment: Should be less than 0.50in. ACCO to provide analysis and reply.					
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Sustainable Design, p. 4 of 11						
001-005	Minor detail: statement regarding 100,000 hour lamp life appears to be a mistake. 10/12/06 Meeting Comment: Glumac to review and reply.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
Sustainable Design, p. 6 of 11						
001-006	Carbon Dioxide Sensing. The submittal states that CO2 will be sensed at the return of each air handling unit to control outside air. Please note that sensing within the individual spaces is likely necessary to achieve LEED credits and meet Title 24 requirements for high occupancy spaces. 10/12/06 Meeting Comment: Information only. D-B Contractor option to utilize if needed for LEED credits.	Mark Chase - JFI	Accepted as Noted			Yes
Sustainable Design, p. 7 of 11						
001-007	System Right Sizing. We agree that avoiding oversizing of cooling compressors and VAV boxes can improve energy performance. However, other forms of oversizing can improve performance, such as larger air handler dimensions (filter and coil face area), air shafts, air ducts, and pipes. 10/12/06 Meeting Comment: VAV boxes should be sized according to load, they should not be oversized.	Mark Chase - JFI	Deferred to CD's			Yes
Sustainable Design, p. 7 of 11						
001-008	Green Power. The State should be aware that the contractor is assuming the State will pay for green power certificates to earn LEED credits. However, this is not a very large investment. 10/12/06 Meeting Comment: Caltrans would need to purchase credits. D-B Contractor cannot count on this for LEED credits.	Richard Myren - DGS;	Accepted as Noted			Yes
Sustainable Design, p. 10 of 11						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
001-009	The submittal describes a proposed goal of 20% energy savings below Title 24-2005. However, the RFP lists a goal of 25%, and the contractor's proposal included a LEED scorecard indicating 5 credits for energy performance, equal to at least 24.5% savings. The concern here is that there could be a "slippage" of the performance target. If the contractor proposes to change the goal, the change should be highlighted and the reasons for the change should be made clear to the State.	Erik Kolderup - AEC;	Req'd Prior to Acceptance			No
Sustainable Design, p. 11 of 11						
001-010	Some of the measures listed as "further enhancements (to baseline designs) were also listed in the RFP Design Guidelines (24.C.8) as design features for the contractor to consider in meeting the 25% energy savings goal. Therefore, it seems that they should not necessarily be presented as additional cost items if they are necessary to meet the overall performance goal listed in the RFP. This comment applies to daylight harvesting system, reduced friction loss in ducts and pipes, and pre-cooling outside air.	Erik Kolderup - AEC;	Req'd Prior to Acceptance			No
Sustainable Design, p. 11 of 11						
001-011	Automatic daylighting controls with dimming ballasts were included in the contractor's original submission (Section E Sustainable Design Enhancements). Therefore, it seems inappropriate to include them in this submission as a potential extra cost item. 10/12/06 Meeting Comment: Not required by RFP, Owner option.	Richard Myren - DGS;	Req'd Prior to Acceptance			Yes
9/26/06 meeting discussion						
001-012	Comfort in perimeter zones. The contractor should confirm that occupant comfort will be maintained in perimeter zones. One issue of potential concern is radiant temperature of the uninsulated concrete columns and beams. Another potential concern is the depth of the perimeter zone served by the fabric duct system and the fact that extra heating or cooling might be needed near the exterior wall relative to space more than 15 feet from the exterior wall. 10/12/06 Meeting Comments: Contractor to provide modelling and calculations to address this issue.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
9/26/06 meeting discussion						
001-013	Comfort and air quality in spaces near the "canyon". Contractor should confirm that adequate ventilation air and comfortable air temperature will be maintained in workstations close to the open core. 10/12/06 Meeting Comment: See item 001-012.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
9/26/06 meeting discussion						
001-014	In a future submittal, contractor should provide details of building pressure control scheme that accounts for the impact of the open "canyon" space. 10/12/06 Meeting Comment:Submittal is in progress.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
9/26/06 meeting discussion						
001-015	Alternatives to R-22 refrigerant should be considered. 10/12/06 Meeting Comment: Alternate source is not	Arlen Arnold - TCC;	Accepted as Noted			Yes

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
	required per the RFP, alternate sources are currently not as efficient.					
9/26/06 meeting discussion						
001-016	Contractor should work with Caltrans to determine requirements for off-hour control capability and to maximize the HVAC and lighting system capability to shut off service to the majority of the building while serving only occupied portions. 10/12/06 Meeting Comment: Contractor to work with Caltrans to get this information.	Arlen Arnold - TCC; Frank Maskovich - CALTRANS;	Req'd Prior to Acceptance			No
9/26/06 meeting discussion						
001-017	Data center airside economizer and related alternatives seem worthy of further study. Caltrans information technology personnel should be consulted for their requirements. 10/12/06 Meeting Comment: Alternate solution is not acceptable by Caltrans.	Mark Chase - JFI	Rejected			Yes
HW Recirculation						
002-001	1. The narrative stated that hot water recirculation would not be incorporated, but in the meeting they clarified that they have changed the approach and recirculation will be incorporated. 10/12/06 Meeting Comment: For Information Only.	Mark Chase - JFI	Accepted as Noted			Yes
DW Booster Pump						
002-002	2. They indicated that the domestic water booster would be housed in small utility building adjacent the main building. 10/12/06 Meeting Comment: Need for booster pump is still to be determined.	Arlen Arnold - TCC;	Accepted as Noted			No
Rainwater Leaders						
002-003	3. There was considerable discussion regarding rainwater leaders and roof drains/overflows. The criteria limited the amount of roof area served by an individual drain. The Architect also restricted the use of scupper type overflows. The combination of these two items created numerous vertical piping drops within the building that are exposed per the architectural approach. We stated that we would be willing to recommend the State relax the area limitation pursuant to a layout which could demonstrate positive drainage. We also expressed concern over noise from rainwater leaders exposed within the occupied space. The Design/Builder was going to have their team's acoustical consultant review and advise. 10/12/06 Meeting Comment: ACCO has been able to reduce number of drains and will present new proposal at a later date.	Arlen Arnold - TCC;	Deferred to CD's			Yes
Water Heating						
002-004	4. We asked that the Design/Builder submit documentation regarding the requirement of solar or renewable energy water heating was not cost effective. 10/12/06 Meeting Comment: ACCO to provide cost analysis. 10/24/06 Lowell Shields: ACCO need to send analysis thru channels for review in order to close this item.	Lowell Shields (CEC)	Req'd Prior to Acceptance			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
Waterless Urinals						
002-005	5. We questioned if the State had any issues/concerns with the use of waterless urinals or if they had any procurement issues with the proprietary chemicals for cleaning, sanitizing and operating the urinals. The response was generally acceptable, however the Design/Builder agreed to review the LEEDTM point count to see if elimination of the waterless urinals would jeopardize their LEED certification level. 10/12/06 Meeting Comment: LEED points may be needed for these.	Lowell Shields (CEC)	Deferred to CD's			No
Toilet Valves						
002-006	6. Segregation valves were discussed and the Design/Builder noted that each toilet core was valved separately. 10/12/06 Meeting Comment: Verified and closed.	Arlen Arnold - TCC;	Accepted as Noted			Yes
Piping Installation						
002-007	7. Wet-columns were discussed and the Design/Builder agreed to re-look at their layouts so there were no significant portions of the facility that were unreachable with water and waste. 10/12/06 Meeting Comment: This has been resolved and will be presented in next design submission.	Arlen Arnold - TCC;	Deferred to CD's			No
1. The main rooftop HVAC units are configured as large capacity, water cooled units manufactured by Petra, an overseas company. We raised several points:						
002-008	 The units are very long and relatively tall. When they extend in the direction of the roof slope, they start with a five foot curb height and get further off the roof surface and thus are inaccessible without service catwalks or rolling platforms with stair or ladders, all in conformance with OSHA. ACCO agreed to review and come back with a proposed solution to address.  The units are foreign made, but likely use mostly domestic parts. ACCO agreed to provide a parts list for the State so they could validate that critical parts would be readily available/serviceable.  We requested clarification of the refrigerant type on the unit. ACCO responded that it was R-22, but they agreed to find out if the manufacturer offered alternate refrigerants and what the additional cost would be. 10/12/06 Meeting Comment: These items will be addressed in the next design submission	Arlen Arnold - TCC;	Approved as Noted			No
Unit Sizing						
002-009	2. ACCO brought up the concern that the units were likely oversized due to the prescriptive criteria relative to internal loads and required oversizing. They agreed to provide some data to allow the State to evaluate whether the criteria should be relaxed. Apparently some field data is also being gathered from one or more of Caltrans' existing facilities. 10/12/06 Meeting Comment: Further information will be in next design submission.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
HVAC System Water Treatment						
002-010	3. We asked what type of water treatment was planned for the cooling towers. ACCO responded that it was conventional chemical treatment.	William Finney - RMW;	Req'd Prior to Approval			Yes

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
Ductwork						
002-011	4. We discussed the use of the fabric ductwork and ACCO agreed to get an installation reference list for the State on similar applications. We expressed the concern that the exterior zone may have the need for more air than an interior space yet most of the runs cover both spaces. ACCO was going to research whether this is an issue and how it might be addressed. We also talked a little bit about the acoustical concerns. On one aspect, diffuser noise, the fabric duct is very positive, but does not mitigate duct born noise well, so it wouldn't be able to attenuate the VAV box noise very well. They were going to discuss with the acoustical consultant. Also, please note cleaning requirements and provisions for such. 10/12/06 Meeting Comment: Further information will be provided.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			Yes
BMS System						
002-012	5. We asked about the BMS system and were told their selection has not been finalized yet. 10/12/06 Meeting Comment: Information will be provided in the CD drawings.	Arlen Arnold - TCC;	Req'd Prior to Approval			No
Zoning						
002-013	6. We briefly discussed zoning and it was apparent that significant differences still exist between the architectural plans and the mechanical so it would be prudent to differ that review until later. 10/12/06 Meeting Comment: Further information will be provided.	Arlen Arnold - TCC;	Req'd Prior to Approval			No
Roof Walk Overs						
002-014	7. We requested the Design/Builder address the access and 'walk-overs' for the significant amount of outdoor piping and equipment on the roof. 10/12/06 Meeting Comment: Further design information is needed to determine the need for these.	Arlen Arnold - TCC;	Req'd Prior to Approval			No
Redundancy						
002-015	8. The RFP criteria requires some measure of reliability/redundancy in the main HVAC system so that if a big central unit goes down, then major expanses of the building are not down and have no conditioning. The use of four air handling units satisfies that criteria	Lowell Shields (CEC)	Approved as Noted			Yes
Distribution-Zoning						
002-016	9. Eric raised a question at the end of the discussion as to whether the distribution approach addresses the 'gridding' or 'looping' called for in the criteria. The DB replied that they have not included that and did not provide an explanation, however it appeared it was somewhat self evident from the approach of locating the VAV terminal close to the core for architectural/acoustical reasons and is tied to the approach of utilizing fabric duct for the final distribution. The looping philosophy is important with large expanses of tenant space that could be sub-zoned in the future to facilitate the introduction of additional zone terminals. It appears the architectural layout doesn't lend itself to that need, however we will keep attention to that point during the detailed distribution review.	William Finney - RMW;	Req'd Prior to Approval			Yes

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
	10/12/06 Meeting Comment: This should not be applicable to this design.					
Canyon Heat Migration						
002-017	10. Richard Myren brought up two main issues for him, one being the 'canyon' heat migration and the other being the uninsulated concrete wall. In a short discussion, it was thought that pressurization relief through this space would be adequate to prevent stack effect and stratification problem. We will await ACCO's proposed solution for this and will comment further at that time. The un-insulated concrete however is a bigger concern. Glumac, the energy consultant for Turner, agreed to address through a load simulation analysis and report back. 10/12/06 Meeting Comment: ACCO will address this issue in future design submissions.	Arlen Arnold - TCC;	Req'd Prior to Approval			No
11. We talked briefly about the following life cycle cost suggestions:						
002-018	Data Center and IT closed economizer- CECI agreed to draft a memo to be forwarded to Caltrans IT for review and comment. b. Pre-cooling outside air at the four main units using the condenser water system-ACCO to work with Glumac to analyze, price and LCCA.	William Finney - RMW;	Req'd Prior to Acceptance			Yes
We also reviewed the binders and plans sent prior to the systems confirmation meeting and the following are our comments on that material:						
002-019		William Finney - RMW;	Accepted as Noted			No
AC0.2						
002-020	1. The fire/smoke damper schedule notes Ruskin FSD-36 although ACCO confirmed in the meeting that they would also be using some FSD-60. 2. Under the Pump schedule, the proposed pumps listed are end-suction centrifugal type, which according the criteria may only be used for flow rates below 500 gpm, however we will entertain the alternative pursuant to a suitable comparison of benefits to the State for acceptance of the alternate pump type. 10/12/06 Meeting Comment: This issue will be addressed in future design submissions.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
P-001						
002-021	1. The piping material schedule deviates from the performance specifications in the use of "M" copper for above grade domestic hot and cold water. Only "L" is allowed by the criteria. 2. The pipe hanger schedule deviates from the performance specifications in the rod size requirements for cast iron piping. 10/12/06 Meeting Comment: The material will be changed in future submissions.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
P-205 & P-206						
002-022	In future submissions, note the roof area served by each drain. 10/12/06 Meeting Comments: Will be in future submissions.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
ACCO Plumbing Narrative and Product Information Binder						
002-023	1. Regarding hose bibb's, they must facilitate access to all areas with a 50 ft. maximum hose. 2. The grease traps must comply with local health department regulations. 10/12/06 Meeting Comment: Hose bibs will be shown on landscape drawings. Grease traps will depend on input from Health Dept.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
ACCO Plumbing Narrative and Product Information Binder						
002-024	1. Tabs1 and 3-11- No comments 2. Tab 2- Architect would prefer an under-counter mounted fixture in lieu of countertop self-rimming style. 3. Tab 12- The criteria requires a triplex pressure booster station; a duplex has been proposed. 4. Tabs 13-14- No comments	William Finney - RMW;	Req'd Prior to Acceptance			No
ACCO HVAC Systems Confirmation Binder						
002-025	Tab 1- Comments addressed in meeting notes. 2. Tab 2- No comments 3. Tab 3- Edits appear acceptable. 4. Tab 4- Defer review pending acceptance of approach. 5. Tab 5- Review above.	William Finney - RMW;	Accepted as Noted			No
General Comments						
002-026	Overall, the design appears to address the major components of the revised HVAC systems criteria (Chapter 24R) and the plumbing systems criteria (Chapter 23) as well as the specifications although this was not an exhaustive review. All system sizing and equipment selections are subject to review of the calculations. Unless noted above as an exception to the criteria, the written criteria still stands and as the design evolves further we will review accordingly.	William Finney - RMW;	Req'd Prior to Acceptance			Yes

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
RFI #3						
003-001	10/12/06 Meeting Comment:The State is reluctant to deviate from the 4 watts/sf as called for in the RFP. Turner will provide a estimate of cost savings to go to 3 watt/sf for the State to review.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No

Cc:	Company Name	Contact Name	Copies	Notes

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Caltrans District 3 Building Replacement
703 "B" Street
Marysville, CA

Project # W.O.114126
Tel: Fax:

Jacobs Facilities Inc.

Systems Confirmation-HVAC/Plumbing Meeting 3

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001-006	Carbon Dioxide Sensing. The submittal states that CO2 will be sensed at the return of each air handling unit to control outside air. Please note that sensing within the individual spaces is likely necessary to achieve LEED credits and meet Title 24 requirements for high occupancy spaces. 10/12/06 Meeting Comment: Information only. D-B Contractor option to utilize if needed for LEED credits.	Mark Chase - JFI	Accepted as Noted			Yes
Sustainable Design, p. 7 of 11						
001-007	System Right Sizing. We agree that avoiding oversizing of cooling compressors and VAV boxes can improve energy performance. However, other forms of oversizing can improve performance, such as larger air handler dimensions (filter and coil face area), air shafts, air ducts, and pipes. 10/12/06 Meeting Comment: VAV boxes should be sized according to load, they should not be oversized.	Mark Chase - JFI	Deferred to CD's			Yes
Sustainable Design, p. 7 of 11						
001-008	Green Power. The State should be aware that the contractor is assuming the State will pay for green power certificates to earn LEED credits. However, this is not a very large investment. 10/12/06 Meeting Comment: Caltrans would need to purchase credits. D-B Contractor cannot count on this for LEED credits.	Richard Myren - DGS;	Approved as Noted			Yes
Sustainable Design, p. 10 of 11						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
001-009	The submittal describes a proposed goal of 20% energy savings below Title 24-2005. However, the RFP lists a goal of 25%, and the contractor's proposal included a LEED scorecard indicating 5 credits for energy performance, equal to at least 24.5% savings. The concern here is that there could be a "slippage" of the performance target. If the contractor proposes to change the goal, the change should be highlighted and the reasons for the change should be made clear to the State.	Erik Kolderup - AEC;	Approved as Noted			No
Sustainable Design, p. 11 of 11						
001-010	Some of the measures listed as "further enhancements (to baseline designs) were also listed in the RFP Design Guidelines (24.C.8) as design features for the contractor to consider in meeting the 25% energy savings goal. Therefore, it seems that they should not necessarily be presented as additional cost items if they are necessary to meet the overall performance goal listed in the RFP. This comment applies to daylight harvesting system, reduced friction loss in ducts and pipes, and pre-cooling outside air.	Erik Kolderup - AEC;	Approved as Noted			No
Sustainable Design, p. 11 of 11						
001-011	Automatic daylighting controls with dimming ballasts were included in the contractor's original submission (Section E Sustainable Design Enhancements). Therefore, it seems inappropriate to include them in this submission as a potential extra cost item. 10/12/06 Meeting Comment: Not required by RFP, Owner option. 11/30/06: These controls will be confirmed in the electrical submittals.	Richard Myren - DGS;	Approved as Noted			Yes
9/26/06 meeting discussion						
001-012	Comfort in perimeter zones. The contractor should confirm that occupant comfort will be maintained in perimeter zones. One issue of potential concern is radiant temperature of the uninsulated concrete columns and beams. Another potential concern is the depth of the perimeter zone served by the fabric duct system and the fact that extra heating or cooling might be needed near the exterior wall relative to space more than 15 feet from the exterior wall. 10/12/06 Meeting Comments: Contractor to provide modelling and calculations to address this issue. 11/30/06: Refer to letter issued by RMW and Capital Engineering dated November 27,2006 as well as letter from Jacobs issued 11/30/06.	Arlen Arnold - TCC;	Deferred to CD's			No
9/26/06 meeting discussion						
001-013	Comfort and air quality in spaces near the "canyon". Contractor should confirm that adequate ventilation air and comfortable air temperature will be maintained in workstations close to the open core. 10/12/06 Meeting Comment: See item 001-012.	Arlen Arnold - TCC;	Approved as Noted			No
9/26/06 meeting discussion						
001-014	In a future submittal, contractor should provide details of building pressure control scheme that accounts for the impact of the open "canyon" space. 10/12/06 Meeting Comment:Submittal is in progress.	Arlen Arnold - TCC;	Approved as Noted			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
9/26/06 meeting discussion						
001-015	Alternatives to R-22 refrigerant should be considered. 10/12/06 Meeting Comment: Alternate source is not required per the RFP, alternate sources are currently not as efficient.	Arlen Arnold - TCC;	Approved as Noted			Yes
9/26/06 meeting discussion						
001-016	Contractor should work with Caltrans to determine requirements for off-hour control capability and to maximize the HVAC and lighting system capability to shut off service to the majority of the building while serving only occupied portions. 10/12/06 Meeting Comment: Contractor to work with Caltrans to get this information.	Arlen Arnold - TCC; Frank Maskovich - CALTRANS;	Approved as Noted			No
9/26/06 meeting discussion						
001-017	Data center airside economizer and related alternatives seem worthy of further study. Caltrans information technology personnel should be consulted for their requirements. 10/12/06 Meeting Comment: Alternate solution is not acceptable by Caltrans.	Mark Chase - JFI	Rejected			Yes
HW Recirculation						
002-001	1. The narrative stated that hot water recirculation would not be incorporated, but in the meeting they clarified that they have changed the approach and recirculation will be incorporated. 10/12/06 Meeting Comment: For Information Only.	Mark Chase - JFI	Approved as Noted			Yes
DW Booster Pump						
002-002	2. They indicated that the domestic water booster would be housed in small utility building adjacent the main building. 10/12/06 Meeting Comment: Need for booster pump is still to be determined.	Arlen Arnold - TCC;	Accepted as Noted			No
Rainwater Leaders						
002-003	3. There was considerable discussion regarding rainwater leaders and roof drains/overflows. The criteria limited the amount of roof area served by an individual drain. The Architect also restricted the use of scupper type overflows. The combination of these two items created numerous vertical piping drops within the building that are exposed per the architectural approach. We stated that we would be willing to recommend the State relax the area limitation pursuant to a layout which could demonstrate positive drainage. We also expressed concern over noise from rainwater leaders exposed within the occupied space. The Design/Builder was going to have their team's acoustical consultant review and advise. 10/12/06 Meeting Comment: ACCO has been able to reduce number of drains and will present new proposal at a later date.	Arlen Arnold - TCC;	Deferred to CD's			Yes
Water Heating						
002-004	4. We asked that the Design/Builder submit documentation regarding the requirement of solar or renewable energy water heating was not cost effective. 10/12/06 Meeting Comment: ACCO to provide cost	Lowell Shields (CEC)	Deferred to CD's			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
	analysis. 10/24/06 Lowell Shields: ACCO need to send analysis thru channels for review in order to close this item.					
Waterless Urinals						
002-005	5. We questioned if the State had any issues/concerns with the use of waterless urinals or if they had any procurement issues with the proprietary chemicals for cleaning, sanitizing and operating the urinals. The response was generally acceptable, however the Design/Builder agreed to review the LEEDTM point count to see if elimination of the waterless urinals would jeopardize their LEED certification level. 10/12/06 Meeting Comment: LEED points may be needed for these.	Lowell Shields (CEC)	Rejected			No
Toilet Valves						
002-006	6. Segregation valves were discussed and the Design/Builder noted that each toilet core was valved separately. 10/12/06 Meeting Comment: Verified and closed.	Arlen Arnold - TCC;	Approved as Noted			Yes
Piping Installation						
002-007	7. Wet-columns were discussed and the Design/Builder agreed to re-look at their layouts so there were no significant portions of the facility that were unreachable with water and waste. 10/12/06 Meeting Comment: This has been resolved and will be presented in next design submission.	Arlen Arnold - TCC;	Deferred to CD's			No
1. The main rooftop HVAC units are configured as large capacity, water cooled units manufactured by Petra, an overseas company. We raised several points:						
002-008	 The units are very long and relatively tall. When they extend in the direction of the roof slope, they start with a five foot curb height and get further off the roof surface and thus are inaccessible without service catwalks or rolling platforms with stair or ladders, all in conformance with OSHA. ACCO agreed to review and come back with a proposed solution to address.  The units are foreign made, but likely use mostly domestic parts. ACCO agreed to provide a parts list for the State so they could validate that critical parts would be readily available/serviceable.  We requested clarification of the refrigerant type on the unit. ACCO responded that it was R-22, but they agreed to find out if the manufacturer offered alternate refrigerants and what the additional cost would be. 10/12/06 Meeting Comment: These items will be addressed in the next design submission	Arlen Arnold - TCC;	Approved as Noted			No
Unit Sizing						
002-009	2. ACCO brought up the concern that the units were likely oversized due to the prescriptive criteria relative to internal loads and required oversizing. They agreed to provide some data to allow the State to evaluate whether the criteria should be relaxed. Apparently some field data is also being gathered from one or more of Caltrans' existing facilities. 10/12/06 Meeting Comment: Further information will be in next design submission.	Arlen Arnold - TCC;	Rejected			No
HVAC System Water Treatment						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
002-010	3. We asked what type of water treatment was planned for the cooling towers. ACCO responded that it was conventional chemical treatment.	William Finney - RMW;	Approved as Noted			Yes
Ductwork						
002-011	4. We discussed the use of the fabric ductwork and ACCO agreed to get an installation reference list for the State on similar applications. We expressed the concern that the exterior zone may have the need for more air than an interior space yet most of the runs cover both spaces. ACCO was going to research whether this is an issue and how it might be addressed. We also talked a little bit about the acoustical concerns. On one aspect, diffuser noise, the fabric duct is very positive, but does not mitigate duct born noise well, so it wouldn't be able to attenuate the VAV box noise very well. They were going to discuss with the acoustical consultant. Also, please note cleaning requirements and provisions for such. 10/12/06 Meeting Comment: Further information will be provided. 11/30/06: Fabric ducts are being changed to metal ducts per Steve Schultz. A design submittal prior to CD's is being prepared.	Arlen Arnold - TCC;	Deferred to CD's			Yes
BMS System						
002-012	5. We asked about the BMS system and were told their selection has not been finalized yet. 10/12/06 Meeting Comment: Information will be provided in the CD drawings.	Arlen Arnold - TCC;	Deferred to CD's			No
Zoning						
002-013	6. We briefly discussed zoning and it was apparent that significant differences still exist between the architectural plans and the mechanical so it would be prudent to differ that review until later. 10/12/06 Meeting Comment: Further information will be provided.	Arlen Arnold - TCC;	Deferred to CD's			No
Roof Walk Overs						
002-014	7. We requested the Design/Builder address the access and 'walk-overs' for the significant amount of outdoor piping and equipment on the roof. 10/12/06 Meeting Comment: Further design information is needed to determine the need for these.	Arlen Arnold - TCC;	Deferred to CD's			No
Redundancy						
002-015	8. The RFP criteria requires some measure of reliability/redundancy in the main HVAC system so that if a big central unit goes down, then major expanses of the building are not down and have no conditioning. The use of four air handling units satisfies that criteria	Lowell Shields (CEC)	Approved as Noted			Yes
Distribution-Zoning						
002-016	9. Eric raised a question at the end of the discussion as to whether the distribution approach addresses the 'gridding' or 'looping' called for in the criteria. The DB replied that they have not included that and did not provide an explanation, however it appeared it was somewhat self evident from the approach of locating the VAV terminal close to the core for architectural/acoustical reasons and is tied to the approach	William Finney - RMW;	Deferred to CD's			Yes

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
	of utilizing fabric duct for the final distribution. The looping philosophy is important with large expanses of tenant space that could be sub-zoned in the future to facilitate the introduction of additional zone terminals. It appears the architectural layout doesn't lend itself to that need, however we will keep attention to that point during the detailed distribution review. 10/12/06 Meeting Comment: This should not be applicable to this design.					
Canyon Heat Migration						
002-017	10. Richard Myren brought up two main issues for him, one being the 'canyon' heat migration and the other being the uninsulated concrete wall. In a short discussion, it was thought that pressurization relief through this space would be adequate to prevent stack effect and stratification problem. We will await ACCO's proposed solution for this and will comment further at that time. The un-insulated concrete however is a bigger concern. Glumac, the energy consultant for Turner, agreed to address through a load simulation analysis and report back. 10/12/06 Meeting Comment: ACCO will address this issue in future design submissions.	Arlen Arnold - TCC;	Approved as Noted			No
11. We talked briefly about the following life cycle cost suggestions:						
002-018	Data Center and IT closed economizer- CECI agreed to draft a memo to be forwarded to Caltrans IT for review and comment. b. Pre-cooling outside air at the four main units using the condenser water system-ACCO to work with Glumac to analyze, price and LCCA.	William Finney - RMW;	Rejected			Yes
We also reviewed the binders and plans sent prior to the systems confirmation meeting and the following are our comments on that material:						
002-019		William Finney - RMW;	Approved as Noted			No
AC0.2						
002-020	1. The fire/smoke damper schedule notes Ruskin FSD-36 although ACCO confirmed in the meeting that they would also be using some FSD-60. 2. Under the Pump schedule, the proposed pumps listed are end-suction centrifugal type, which according the criteria may only be used for flow rates below 500 gpm, however we will entertain the alternative pursuant to a suitable comparison of benefits to the State for acceptance of the alternate pump type. 10/12/06 Meeting Comment: This issue will be addressed in future design submissions.	Arlen Arnold - TCC;	Deferred to CD's			No
P-001						
002-021	1. The piping material schedule deviates from the performance specifications in the use of "M" copper for above grade domestic hot and cold water. Only "L" is allowed by the criteria. 2. The pipe hanger schedule deviates from the performance specifications in the rod size requirements for cast iron piping. 10/12/06 Meeting Comment: The material will be changed in future submissions.	Arlen Arnold - TCC;	Approved as Noted			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
P-205 & P-206						
002-022	In future submissions, note the roof area served by each drain. 10/12/06 Meeting Comments: Will be in future submissions. 11/30/06: Information will be provided in roof system submittals.	Arlen Arnold - TCC;	Deferred to CD's			No
ACCO Plumbing Narrative and Product Information Binder						
002-023	1. Regarding hose bibb's, they must facilitate access to all areas with a 50 ft. maximum hose. 2. The grease traps must comply with local health department regulations. 10/12/06 Meeting Comment: Hose bibs will be shown on landscape drawings. Grease traps will depend on input from Health Dept.	Arlen Arnold - TCC;	Approved as Noted			No
ACCO Plumbing Narrative and Product Information Binder						
002-024	1. Tabs1 and 3-11- No comments 2. Tab 2- Architect would prefer an under-counter mounted fixture in lieu of countertop self-rimming style. 3. Tab 12- The criteria requires a triplex pressure booster station; a duplex has been proposed. 4. Tabs 13-14- No comments	William Finney - RMW;	Approved as Noted			No
ACCO HVAC Systems Confirmation Binder						
002-025	Tab 1- Comments addressed in meeting notes. 2. Tab 2- No comments 3. Tab 3- Edits appear acceptable. 4. Tab 4- Defer review pending acceptance of approach. 5. Tab 5- Review above.	William Finney - RMW;	Approved as Noted			No
General Comments						
002-026	Overall, the design appears to address the major components of the revised HVAC systems criteria (Chapter 24R) and the plumbing systems criteria (Chapter 23) as well as the specifications although this was not an exhaustive review. All system sizing and equipment selections are subject to review of the calculations. Unless noted above as an exception to the criteria, the written criteria still stands and as the design evolves further we will review accordingly.	William Finney - RMW;	Approved as Noted			Yes

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
RFI #3						
003-001	10/12/06 Meeting Comment:The State is reluctant to deviate from the 4 watts/sf as called for in the RFP. Turner will provide a estimate of cost savings to go to 3 watt/sf for the State to review.	Arlen Arnold - TCC;	Rejected			No

Cc:	Company Name	Contact Name	Copies	Notes

Meeting Minutes

Detailed (Editable), Grouped by Each Meeting and by 'Old Business' and 'New Business'

Caltrans District 3 Building Replacement
703 "B" Street
Marysville, CA

Project # W.O.114126
Tel: Fax:

Jacobs Facilities Inc.

Systems Review-Exterior Enclosure Meeting 2

Date	Start	End	Next Meeting	Next Time	Prepared By	Company
10/5/2006	09:30 AM	02:30 PM	10/12/2006	09:30 AM	Mark Chase	Jacobs Facilities Inc.

Purpose	Location	Next Location	General Notes
Review Comments generated by State team and Comments provided in response by the Design Build team. Further comments made in the meeting are noted in items.	Caltrans Sacramento 2389 Gateway Oaks Main Conference Room	Clark Pacific Casting Facility1980 South River RoadWest Sacramento, CA 95691	This review is limited to the information provided to RMW by the Design Builder and is based on the conformance of the information given to the approved schematic design, the design guidelines, conceptual drawings, performance criteria and all addendums included in the Request For Proposal documents. The Design Builder remains responsible for determining the accuracy and completeness of the submittals and for substantiating the performance of equipment or systems. Comments on the systems confirmation submittals during this review do not relieve the Design Builder of its responsibility to comply with the requirements of the Proposal Documents. SEE COMMENTS NOTED ADDITIONAL SUBMITTALS REQUIRED STATUS DEFINITIONS: ACCEPTED AS NOTED: Information is sufficient to proceed with design anticipating Turner will incorporate this item. REQUIRED PRIOR TO ACCEPTANCE: Further information needs to be provided prior to potential acceptance of this item. DEFERRED TO CD's: Design can proceed through Construction Documents while further information is being generated by Turner and provided for further review/acceptance.

Attended By	Non-Attendees
Turner Construction Company - Toby Leitch	
Jacobs Facilities Inc. - Mark Chase	
California Transportation Dept - Frank Maskovich	
California Transportation Dept - Glenn Yee	

Meeting Minutes
Detailed (Editable), Grouped by Each Meeting and by 'Old Business' and 'New Business'

Attended By
RMW Architecture and Interiors - William Finney
Department of General Services - Wes Hubbart
Department of General Services - Burton Shanoff
Turner Construction Company - Steve Schultz
Turner Construction Company - Arlen Arnold
Forell/Elsesser - Mason Walters

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
Review of Systems Confirmation – Exterior Enclosure of submittal package dated September 21, 2006 includes the following documents:						
002-001	•B20 – Exterior Enclosure Narrative •Drawings (includes reconfigured floor plates): A201 thru 205, A2R1, A501 thru 503, A505 thru A508, A601, EP-02 thru EP-06, ES-01 thru ES-02, EE-07 thru EE-09, S-201 thru S-206, S-411 thru S-412, AC0.1 thru ACO.2, AC1.3, AC1.5 thru AC1.6, AC1.1Z thru AC1.5Z, E00, E1.1, EL2.3, EP2.3, ED-3.1. •Sample: Solarban 70XL on Starphire Glass PPG	William Finney - RMW;	Closed			Yes
Architectural Comments to Systems Confirmation Submittal – Exterior Enclosure by Bill Finney / RMW:						
002-002	The exterior elevations are not noted and are used primarily for keying the wall sections. Review comments are limited to the overall building massing and openings which may effect the precast concrete work.	William Finney - RMW;	Accepted as Noted			Yes
002-003	Comparison of the Exterior Elevations between the RFP response and current submittal: West Elevation: -Wood shading Lattice Between col Lines 4 and 5 is not shown. Is this for clarity? Precast and cement board building screen element above the 5th floor between col lines 2 and 4 has been deleted, exposing the elevator penthouse. East Elevation: -Number and location of cement board in-fill elements has changed. Is this to reflect revisions to the space plan? North Elevation: -Curtain wall element between col lines C and E has been replaced with cement board in-fills. This changes the massing of the building and does not appear to be driven by the space plan. South Elevation: -The curtain wall element has been reduced between col lines B and E. - Wood shading lattice between col lines J and L is not shown. Is this for clarity? TACMP Comment: These items were addressed in the narrative of our RFP to the State. Will discuss at meeting. 10/5/06 Meeting Comment: North elevation changes are due to location of property line. East Elevation: this is correct. South Elevation: This is correct. The RTU screen will depend on sight line studies to be conducted.	William Finney - RMW;	Req'd Prior to Approval			Yes

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
002-004	Overflow scuppers through the high roof parapets will not be acceptable. TACMP Comment: We are still reviewing the roof drain design and overflow scuppers have not been completely ruled out.	William Finney - RMW;	Req'd Prior to Approval			Yes
002-005	Roof mounted HVAC equipment will be exposed above the parapet. In keeping with the "elegant and well proportioned" elevations, will this equipment be screened per Addendum 1 AS9, if so how? Will the city design guidelines allow exposed roof mounted equipment? TACMP Comment: B-Street side is screened, we will be evaluating the need to screen other sides and discuss.	William Finney - RMW;	Req'd Prior to Acceptance			No
002-006	Window detail 3/A-505, slope concrete sill beyond window frame to allow water to drain away from frame. TACMP Comment: Sills may be sloped in certain conditions. These details will be worked out as the construction documents are produced. 10/5/06 Meeting Comment: This detail will be changed.	William Finney - RMW;	Accepted as Noted			No
002-007	Window detail 15/A-506, How is the extruded alum floor closer sealed at the top under the window frame? Sealant condition is not the same as the head below, which will allow water to run behind the closer. TACMP Comment: Need to discuss with window subcontractor and coordinate with the precast details. 10/5/06 Meeting Comment: Eyebrow ledge should be sloped down.	William Finney - RMW;	Req'd Prior to Acceptance			No
002-008	Provide calculations of the thermal lag for the exterior concrete wall mass. These calculations are to illustrate that the walls will perform as intended, and not impact the comfort of users working along the exterior wall. Concern is that the wall not be hot in the summer or cold in the winter. TACMP Comment: An energy study is under way and will be utilized in finalizing calculations and design for compliance.	William Finney - RMW;	Req'd Prior to Acceptance			No
002-009	Will the interior finish of the precast concrete wall be a monolithic gray color? From the tour at CP, the interior face of a panel may have various concrete colors depending on the exterior finish is poured.	William Finney - RMW;	Accepted as Noted			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
	TACMP Comment: Interior will be standard gray concrete in color.					
002-010	During tour at CP a request was made to use an existing reduced scale testing panel as the mock-up required for this building. This will not be acceptable. Provide Field Sample Panels and Mock-ups specific for this building as described in section 033300 1.5. Because the interior face of the panels will be exposed, mock-ups are to show the interior finish color(s), texture, and detailing expected to be installed. TACMP Comment: Sample panels will be provided for texture and colors. The actual building precast frame will be utilized for water testing the window frame and glass in lieu of a full scale mock-up.	William Finney - RMW;	Accepted as Noted			No
002-011	Composite plank flooring needs to provide slope to floor drains in the toilet room per CPC. TACMP Comment: Topping slab will be sloped to drain where required.	William Finney - RMW;	Accepted as Noted			No
002-012	Relocate gas meter along north wall, away from main entry. TACMP Comment: Yes	William Finney - RMW;	Approved as Noted			No
002-013	Because the duct work, conduits, piping, drains, etc are fully exposed to the interior, coordination of the layout is critical. Utility runs must be minimize, grouped together, parallel or perpendicular to structural elements as much as possible. Locate drains to minimize noise impact on users. TACMP Comment: Yes	William Finney - RMW;	Req'd Prior to Acceptance			No
002-014	Confirm that a fire booster pump will not be necessary? TACMP Comment:Not needed at this time.	William Finney - RMW;	Req'd Prior to Acceptance			No
Structural Comments to Systems Confirmation Submittal – Exterior Enclosure by Mason Walters / Forell/Elsessser:General Comments						
002-015	1. It is evident that the seismic lateral force-resisting system is intended to be a precast/post-tensioned concrete hybrid moment-resisting frame. This system is recently developed and generally recognized by the structural engineering profession in California, but provisions for design of the hybrid moment frame are not specifically covered in the	Mason Walters - FE;	Req'd Prior to Acceptance			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
	CBC. Some type of statement of the basis of design to be used should be provided to explain how the EOR intends to meet the structural design requirements of the CBC. TACMP Comment: Engineering is self certifying. Structural engineer will verify compliance requirements. 10/5/06 Meeting Comment: Mason to review narrative that was supplied to him at this meeting. Response will be sent to Turner by 10/12.					
002-016	2. Structural design parameters relative to important aspects of the structural requirements should be provided to respond to the contractual requirement to depict the design and general coordination, such as: • Areas and parameters for stiff floor areas for computer rooms, in accordance with article C.3 of the Structural Design Criteria, • File and storage weights and locations, in coordination with the architectural floor plans, • Floor flatness and levelness, in accordance with article G.3 of the Structural Design Criteria. TACMP Comment: All of these items have been addressed and additional information will be included in final concrete notes and specifications. 10/5/06 Meeting Comments: CD's will identify HD storage on Structural plans. Cannot modify or delete the floor flatness or floor levelness specification that is in the RFP.	Mason Walters - FE;	Req'd Prior to Acceptance			No
Structural Comments to Systems Confirmation Submittal – Exterior Enclosure by Mason Walters / Forell/Elsessser:Specific Comments						
002-017	Sheet S-201: Area and depth of over-excavation and re-compaction are not indicated, relative to the preliminary geotechnical report referred to in article B.1b of the Structural Design Criteria. TACMP Comment: Design is per the existing soils report from the RFP. A new soils report is in the process of being issued. Any changes due to differences in the two reports will be addressed at that time. 10/5/06 Meeting Comment: Geotech report should be available around 10/19 and will identify areas of over excavation.	Mason Walters - FE;	Req'd Prior to Acceptance			No
002-018	Sheets S-201-S-206: Floor framing for gravity loads is not indicated, including beams and planks, and overall floor plate depth is not indicated. TACMP Comment:Shown on precast drawings at this time.	Mason Walters - FE;	Req'd Prior to Acceptance			No
002-019	Sheets S-201-S-206: Special file storage areas requiring high support capacity, such as the “row files” area noted on Sheet A-202 between grids H-J/2-3 are not shown. TACMP Comment: Shown on Architectural Drawings at	Mason Walters - FE;	Req'd Prior to Acceptance			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
	this time. Will be shown on Precast drawings as they progress.					
002-020	Sheets S-205, S-206: Magnitudes and locations of significant mechanical loads, such as for the 45,000 lb air handlers shown on the mechanical roof plans, are not indicated. TACMP Comment: Precast calculations will indicate this data and design.	William Finney - RMW;	Deferred to CD's			No
002-021	Sheets S-205, S-206: The framing for the large area to be covered by metal roofing (between grids D-5/3-4) indicated on sheets A-2R1 and A-601 is not indicated. TACMP Comment: This will be in-fill framing with structural steel members. These drawings will be issued at a later date but should not require a confirmation submittal.	Mason Walters - FE;	Req'd Prior to Acceptance			No
002-022	Sheet S-401: The post-tensioning for the seismic beams at floors 3 and 4, and for the roof level, is not indicated. TACMP Comment: This information is within the drawings issued.	Mason Walters - FE;	Deferred to CD's			No
Specific Comments:Coordination						
002-023	Sheet A-503: Exterior wall sections do not correctly show the seismic frame beams. TACMP Comment: All possible sections have not been produced at this level. Added sections will be in final drawings which will show the information in question.	Mason Walters - FE;	Req'd Prior to Acceptance			No
002-024	Sheet A-502: The 1" gap, and the presumed need for substantial caulking, shown at the ends of the spandrel upturned curb walls on Sheet S-412, are not indicated on the architectural drawings. TACMP Comment: Not sure what your asking in this item. 10/5/06 Comment: Joints will be caulked. 3/4" joint will be used if possible.	Mason Walters - FE;	Accepted as Noted			No
002-025	"EP" drawings: These drawings reference numerous sections on "ES" sheets, none of which exist in the submittal. TACMP Comment: EP and ES sheets were issued.	Mason Walters - FE;	Accepted as Noted			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
002-026	The absence of plumbing drawings prevented the review of structure-plumbing coordination. TACMP Comment: This package was not for plumbing confirmation. 10/5/06 Meeting Comment: Mason will review with plumbing drawings when they are available.	Mason Walters - FE;	Accepted as Noted			No
002-027	Sheets A-506–A-508: These sheets are erroneously titled “Sheet Index.” TACMP Comment: Will be corrected.	Mason Walters - FE;	Accepted as Noted			No
002-028	Sheet A-601: The sections on this sheet do not appear to be referenced on the drawings TACMP Comment: Will be corrected.	Mason Walters - FE;	Accepted as Noted			No
Attachments Submitted for Review						
002-029	•B20 – Exterior Enclosure Narrative •Drawings (includes reconfigured floor plates): A201 thru 205, A2R1, A501 thru 503, A505 thru A508, A601, EP-02 thru EP-06, ES-01 thru ES-02, EE-07 thru EE-09, S-201 thru S-206, S-411 thru S-412, AC0.1 thru ACO.2, AC1.3, AC1.5 thru AC1.6, AC1.1Z thru AC1.5Z, E00, E1.1, EL2.3, EP2.3, ED-3.1. •Sample: Solarban 70XL on Starphire Glass PPG *Revised Specifications Sections 084113 and 088000 *Specification for Aluminum Framed Entrances and Storefronts *Specification for Glazing *Louver Daylighting Performance Specifications (March 2004)	William Finney - RMW;	Completed			Yes
Specification Review						
002-030	Revised Specifications Section 084113-8.K.3.1.6.A, Section 084113-8.1.6.A, and Section 084113-10.2.2.E.1 have been deleted as part of the submittal. These items should not be deleted and should be included in the design and construction. TACMP Comment: Under review by design team. 10/12/06 Meeting Comment: This information is needed for curtain walls.	William Finney - RMW;	Accepted as Noted			No
General Comments						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
002-031	Systems Confirmation – Exterior Enclosure: Forell/Elsesser Responses to Clark Pacific Meeting on October 5, 2006: This review is limited to the information provided to RMW by the Design Builder and is based on the conformance of the information given to the approved schematic design, the design guidelines, conceptual drawings, performance criteria and all addendums included in the Request For Proposal documents. The Design Builder remains responsible for determining the accuracy and completeness of the submittals and for substantiating the performance of equipment or systems. Comments on the systems confirmation submittals during this review do not relieve the Design Builder of its responsibility to comply with the requirements of the Proposal Documents. No Exceptions Taken See Comments Noted Additional Submittal Required Revise & Resubmit Rejected Date: October 16, 2006 Reviewed By: Mason Walters / Forell/Elsesser Review of Systems Confirmation – Exterior Enclosure: Forell/Elsesser Responses to Clark Pacific Meeting on October 5, 2006 of submittal package dated 9.22.06, includes the following documents: · 9.22.06 “Structural Systems Confirmation” document beginning with “General Design Criteria”. · An edited copy of specification 033000 (Cast-In-Place Concrete), and a tabular open/close summary of design team responses to our latest comments.	Mason Walters - FE;	Accepted as Noted			No
Tabular Summary Comments-Item 002-015						
002-032	1. 002-015: We referred to the structural systems narrative for the response in our review. The explanation of how the structural engineer intends to meet the requirements of the CBC is acceptable.	Mason Walters - FE;	Accepted as Noted			No
Tabular Summary Comments-Item 002-016						
002-033	2. 002-016: The proposed substitution of a ¼” in 10’ criterion for floor finishing tolerance is not in accordance with the Design Guidelines’ requirement for flatness and levelness. Furthermore, the Performance Specifications call for the floors to be tested in accordance with ASTM E1155.	Mason Walters - FE;	Accepted as Noted			No
Tabular Summary Comments-Item 002-017, 018, 019, 020, 021, 022, 023						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
002-034	3. 002-017, 018, 019, 020, 021, 022, 023: The responses to our comments are acceptable.	Mason Walters - FE;	Accepted as Noted			No
Tabular Summary Comments-Item 002-024						
002-035	4. 002-024: We clarified on 10/5/06 that we were interested in the proposed treatment of the parapet to column joint for reasons of water protection and aesthetic consistency. We were told that the gap would be caulked similar to the beam-column joint grout gap, and will look consistent. This is acceptable.	Mason Walters - FE;	Accepted as Noted			No
Tabular Summary Comments-Item 002-026, 027, 028						
002-036	5. 002-026, 027, 028: The responses are acceptable.	Mason Walters - FE;	Accepted as Noted			No
General Design Criteria Document comments						
002-037	1. We found the narrative to be generally consistent with the Design Guidelines.	Mason Walters - FE;	Accepted as Noted			No
Specification Comments						
002-038	1. We noted that section 033000 is for cast in place concrete only and does not include information about pre-cast structural concrete. Thus, the superstructure framing is not addressed in the section reviewed. Pertinent structural components covered under 033000 would include foundations and topping slabs.	Mason Walters - FE;	Accepted as Noted			No
Specification Comments						
002-039	2. 3.10E The proposed language for tolerances would change the floor topping slab finishing tolerance to ¼" in 10' instead of the specified 1/8" in 10'. This is not acceptable, and should be discussed in conjunction with the required flatness and levelness criteria.	Mason Walters - FE;	Accepted as Noted			No

Additional Meeting Attendees:
Nick Bagatelos-Bagatelos Architectural Glass Systems
Jamie Myer-AC Martin Partners
Roger Hearn-DGS Construction Services

Meeting Minutes

Detailed (Editable), Grouped by Each Meeting and by 'Old Business' and 'New Business'

Caltrans District 3 Building Replacement
703 "B" Street
Marysville, CA

Project # W.O.114126
Tel: Fax:

Jacobs Facilities Inc.

Systems Review-Off Site Parking Meeting 3

Date	Start	End	Next Meeting	Next Time	Prepared By	Company
9/28/2006	08:30 AM	11:00 AM			Mark Chase	Jacobs Facilities Inc.

Purpose	Location	Next Location	General Notes
Review preliminary design of offsite parking lot	2389 Gateway Oaks, Main Conference Room Natomas, CA	2389 Gateway Oaks, Main Conference Room Natomas, CA	Meeting to discuss review comments made by State pertaining to design submissions of 9/7/06

Attended By	Non-Attendees
Jacobs Facilities Inc. - Mark Chase	
AC Martin Partners, Inc. - Cary McLeod	
California Transportation Dept - Frank Maskovich	
California Transportation Dept - Glenn Yee	
Department of General Services - Burton Shanoff	
Department of General Services - Richard Myren	
Department of General Services - Wes Hubbart	
Jacobs Facilities Inc. - Ken Adams	
MHM - John Mullen	
RMW Architecture and Interiors - Bill Finney	
Turner Construction Company - Arlen Arnold	
Turner Construction Company - Steve Schultz	
Turner Construction Company - Toby Leitch	

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
Striping						
001-001	Layout achieves 92 cars (text write-up states 90 cars) vs. 83 cars that was shown in the RFP (more is better). The tradeoff is that the West end drive aisle is 13' wide- obviously not "code" compliant but should be sufficient for Caltrans vehicles to navigate around. TACMP Comment: More spaces are available if the handicap spaces are not needed.	William Finney - RMW;	Accepted as Noted			No
Air/Water Supply						
001-002	Water/air pump is not on a drive aisle and therefore not convenient.	William Finney - RMW;	Req'd Prior to Acceptance			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
Electric Car Charging Station						
001-003	It is not clear if the electrical charging unit is being supplied.	William Finney - RMW;	Accepted as Noted			No
Lighting						
001-004	Lighting does not seem uniform. There are no fixtures along 9th or on north side. No photometrics were supplied to validate distribution or amount of illumination.	William Finney - RMW;	Deferred to CD's			No
Security						
001-005	Location of card key station does not work for driveway gate. Adjust location depending on requirements of the security system selected.	William Finney - RMW;	Req'd Prior to Acceptance			No
Security						
001-006	Security cameras and card key systems information will be provided in future reviews with the building systems. Parking lot work to include all necessary services to support these items. The temporary use of a key switch at the gates is acceptable until the card keys are installed.	William Finney - RMW;	Design/Development			No
Lighting						
001-007	Pole light fixture type, numbers of fixtures, and fixture locations on site are to be confirmed with a photometric study. A lighting level of 1 fc min is to be provided.	William Finney - RMW;	Req'd Prior to Acceptance			No
Electric Car Charging Station						
001-008	A Charging Station is shown in both the RFP Case Study layout and the Turner + ACMP C1 drawing. This work is included in the project scope and if deleted for whatever reason, a credit of the costs should be tracked.	William Finney - RMW;	Deferred to CD's			No
Utility Meter						
001-009	A power pole is located in he southwest corner of the site. The electrical meter and irrigation controller will be place in this location. Electrical meter is to be installed so that PGE	William Finney - RMW;	Deferred to CD's			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
	can read the meter without entering the site.					
Gate						
001-010	Information on the driveway gate will be provided in a future submittal. The driveway gate will receive heavy use and needs to provide a short cycling time and be of the highest quality to reduce maintenance.	William Finney - RMW;	Deferred to CD's			No
Striping						
001-011	Parked vehicles are exposed to damage from traffic making tight unprotected turns at the driveway and west isles. Planters, curbs, double stripping combined with additional width may be needed. Discussed using compact stalls along the west to increase the dimension of the drive.	William Finney - RMW;	Deferred to CD's			No
ADA Compliance						
001-012	Show HCP ramp locations on plans.	William Finney - RMW;	Req'd Prior to Acceptance			No
ADA Compliance						
001-013	HCP parking and path of travel to public way may be necessary. Confirm if this will be a requirement of this lot and if so the number of space needed.	William Finney - RMW;	Req'd Prior to Acceptance			No
Existing Conditions						
001-014	Walnut Street fence is +/- 2' off property line because of the sewer location. The planter area between the fence and curb needs to be landscaped and irrigated.	William Finney - RMW;	Req'd Prior to Acceptance			No
Curbs						
001-015	Use continuous concrete curbs in lieu of wheel stops for the south and east parking spaces. Hold the fence in these locations, +/- 2'-6" off the curb and provide low ground cover between the fence and the curb.	William Finney - RMW;	Req'd Prior to Acceptance			No
Security						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
001-016	Would like to see the top of the fence provide more security than a flat rail. What other options are available?	William Finney - RMW;	Deferred to CD's			No
Layout/Survey						
001-017	There should be no large gaps between the fencing and the building north of the parking lot.	William Finney - RMW;	Accepted as Noted			No
Air/Water Supply						
001-018	Relocate the water/air pump for easier access.	William Finney - RMW;	Accepted as Noted			No
Landscaping						
001-019	When a landscape planting and irrigation plan is submitted, provide calculations for the per-cent shading of the paving.	William Finney - RMW;	Accepted as Noted			No
Storm Drains						
001-020	Pavement Grades: The elevations of the pavement seem low. The drain inlet grates are below the curb flow lines on Yuba and 9th Streets, meaning that stormwater will likely back up into the lot during larger storms. Possible solution – raise grades. Also, the release point for drainage water out of the lot would produce water greater than 1' deep in the lot if the storm drain clogged or the capacity was exceeded.	Chuck Cunningham - CE;	Deferred to CD's			No
Storm Drains						
001-021	Storm Drains: Very little cover is provided on the on-site line – only about 6" in some cases. This will make compaction of the base rock very difficult. Possible solutions – raise lot and/or use concrete valley gutters. See above. Also, 6" storm drains are too small for parking lots – too easily clogged. Our office routinely specifies 10" diameter minimum for public lots. Does the 6" line provide capacity? No calculations were provided.	Chuck Cunningham - CE;	Deferred to CD's			No
Pavement Design						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
001-022	Pavement Section: The indicated Traffic Index of 4.5 is consistent with the geotechnical report, as is the AC/AB thicknesses. However, no borings on the subject site were taken as part of the October 2004 study; and the study notes that final pavement design should be based on testing of the compacted subgrade.	Chuck Cunningham - CE;	Req'd Prior to Acceptance			No
Layout/Survey						
001-023	9th Street: It is not clear how the interface between the curb at the west end of 9th will transition to existing improvements at that point.	Chuck Cunningham - CE;	Deferred to CD's			No
Curbs						
001-024	On-Site Curbing: The proposed type of curb is not indicated – the detail sheet shows various options. The geotechnical report does not appear to address, although we recommend a full depth barrier curb to the bottom of the adjoining base rock.	Chuck Cunningham - CE;	Accepted as Noted			No
Curbs						
001-025	Frontage Curb: Not defined – should be vertical, per City Standard Detail 103.	Chuck Cunningham - CE;	Accepted as Noted			No
ADA Compliance						
001-026	Handicap Ramp: The standard detail provided is not appropriate for the condition of a straight across ramp.	Chuck Cunningham - CE;	Req'd Prior to Acceptance			No
Fencing						
001-027	Fencing: As you note, the fencing appears too close to the spaces.	Chuck Cunningham - CE;	Req'd Prior to Acceptance			No
Access						
001-028	Parking Access Control System: Not shown on the plan – can it be installed and properly operated while maintaining all the parking spaces shown?	Chuck Cunningham - CE;	Req'd Prior to Acceptance			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
Security						
001-029	I recommend that they utilize the building's access card and security system to control the vehicle and pedestrian gates. If a revenue control system is designed into the lot, then the access control system and the revenue control system design need to be coordinated. Employees should not carry two access cards.	Teresa Abrahamsohn - TDG;	Accepted as Noted			No
LEED						
001-030	In general, our biggest concern is the lack of a sustainable approach with the design of this parking lot. The Design-Build Support Team had many conversations about creating a sustainable site with this project, but there is no suggestion of sustainability with this portion of the Confirmation Package. The Design-Build Team should reconsider the design of the parking lot to include a bio-filtration swale rather than the typical underground drain inlet and pipe system.	Christine Anderson - HLA;	Deferred to CD's			No
RFP Compliance						
001-031	We also have concern over the lack of clear pedestrian connection internally and from the parking lot to the path of travel along the City sidewalk. The guidelines specifically state the need for a “pedestrian experience” with these connections, but none is noted here.	Christine Anderson - HLA;	Deferred to CD's			No
Landscaping						
001-032	We take no exception to the use of the Zelkova for parking lot shade, but would suggest revisiting the use of the Hackberry due to its propensity for sapping. The guidelines specifically state the use of non-sapping trees for ease of maintenance. Hackberries may be suitable for use in non-paved areas. The use of Kangaroo Paw should be revised as this plant does not grow well in the Marysville area. The overall planting design seems very limited with only 4 plants specified. While a limited palate may be acceptable, it is impossible to tell since the design solution is not provided in plan form. A more complete landscape plan should be submitted. 9/28/06: HLA Group will make recommendations for other types of trees that could be used.	Christine Anderson - HLA;	Req'd Prior to Acceptance			No
Landscaping						
001-033	We have no objection so far to the limited information provided regarding the irrigation system.	Christine Anderson - HLA;	Accepted as Noted			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
Lighting						
001-034	We have no objection to the light standards, but these should be reviewed as well by the electrical engineer for the project. In addition, the placement of light standards should be considered carefully to avoid the placement of standards in tree wells.	Christine Anderson - HLA;	Deferred to CD's			No
City of Marysville						
001-036	The City of Marysville will issue a 30 day Notice of Abandonment for 8th Street. This is anticipated to be issued on 9/19. Property will be deeded to the project if there are no objectionsr.	Richard Myren - DGS;	Information Only		10/18/2006	No
Access						
001-037	A key controlled access for the gate may be needed until the system can be tied into the building.	Cary McLeod - ACMP;	Deferred to CD's			No
Layout/Survey						
001-039	Can move curb line out to where curb stops are located so that there is less maintenance to clean behind curb stops.	John Mullen - MHM;	Deferred to CD's			No
Air/Water Supply						
001-042	Relocate the air/water station to the southwest corner of the parking lot so it is not located in the congested entry area.	Glenn Yee - CALTRANS;	Req'd Prior to Acceptance			No
Lighting						
001-043	Add additional lighting in all four corners of the parking lot to enhance security and provide mountable posts for cameras.	Glenn Yee - CALTRANS;	Accepted as Noted			No
Striping						
001-044	Paint "No Parking Zone" in red on the entire curb along Yuba Street.	Glenn Yee - CALTRANS;	Deferred to CD's			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
Satety						
001-045	Vision is impaired by parallel-parked vehicles on Yuba Street.	Glenn Yee - CALTRANS;	Req'd Prior to Acceptance			No
Striping						
001-046	If the number of parking stalls are to be reduced from the RFP requirements or compact parking stalls are to be utilized in the offsite parking,acceptance must be received by the State.	Glenn Yee - CALTRANS;	Req'd Prior to Acceptance			No
Fencing						
001-047	Fencing should have "devil spikes"	Glenn Yee - CALTRANS;	Accepted as Noted			No
Landscaping						
001-048	All sprinklers to be installed below planter grade. If sprinkler risers are to be utilized, sprinklers shall be below the parking surface/curb grade, be located in areas that vehicles cannot hit them while parking,or utilize flexible risers.	Glenn Yee - CALTRANS;	Accepted as Noted			No
Landscaping						
001-049	Landscaping has been reviewed by District 3 Landscape and is acceptable. Ensure parking lots are landscaped with non-sapping trees, shrubs, and groundcover (RFP - Binder 1, Chapter 14 - Landscape Design, Section C.2.a) and avoid selecting trees with seed pods or fruits that may be attractive to birds or other foraging animals (RFP - Binder 1, Chapter 14 - Landscape Design, Section E.1.b).	Glenn Yee - CALTRANS;	Req'd Prior to Acceptance			No
Striping						
001-050	There is a standard distance in the City of Marysville code for no parking adjacent to a corner and a driveway. When the design is complete and an encroachment permit is issued for the improvements, we would look at the remaining space left for parking and sight distance issues to see if a no parking area is appropriate. This is similar to what we did north of 7th Street on the west side of Yuba	Richard Myren - DGS;	Req'd Prior to Acceptance			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
	Street. At some point, parking north of the driveway would be allowed.					
TACMP Comment						
1-1	Number of stalls will not be reduced from the requirement of the RFP. State to advise if compact stalls are requested in order to increase the stall count.	Arlen Arnold - TCC;	Req'd Prior to Acceptance	(Original: 10/16/2006)		No
TACMP Comment						
1-2	Water/air station will be placed where it will not hinder stall count or design.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-3	Electrical charging unit and water/air station is listed as "possible" in RFP. Turner will provide air/water station only. DGS Comment: Install a empty conduit for future charging station.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-4	Final lighting layout will be designed once the photometric study is completed. Photometric study will be done based on final site design.	Arlen Arnold - TCC;	Deferred to CD's			No
TACMP Comment						
1-5	Card key location will be determined once site layout is finalized and drive aisles and spaces adjusted to meet RFP and code requirements.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-6	Correct, a future meeting with Caltrans/DGS will take place to determine Access Card Security System for entire project. Once the system is determined, the parking lot equipment can be located on the plan and specified.	Arlen Arnold - TCC;	Req'd Prior to Acceptance			No
TACMP Comment						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
1-9	Electric meter and irrigation controller along with power panel will be located near entrance gate close to existing building at the Northeast portion of the site. Meter will be read without entering the site.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-10	Correct	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-11	Final design has addressed this comment. DGS Comment: Review of final design is needed to close item.	Arlen Arnold - TCC;	Deferred to CD's			No
TACMP Comment						
1-13	HCP will be included in final design based on applicable code.	Arlen Arnold - TCC;	Deferred to CD's			No
TACMP Comment						
1-14	Yes	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-15	Yes	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-16	RFP does not require any special condition at top of fence. An alternate can be priced for your consideration. DGS Comment: Contractor to provide pricing for devil spike alternate.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
1-17	Existing site conditions will determine final dimension of gap between fence and existing building. TACMP Comment: Fence will be cantilevered off of post nearest building to close gap.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-19	Final landscaping plan will include calculations for shading achievable based upon 10 growth.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-20	Drainage will be designed per code and will meet City of Marysville standards. Final design will be determined by Engineer of Record to meet code. TACMP Comment: The storm drain line has been relocated to get better drainage.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-22	A new soil sample will be taken by Wallace-Kuhl and R-value for the remote site will be determined prior to finalized design. TACMP Comment: Wallace-Kuhl is testing to determine R value, pavement design is pending results.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-23	Currently there are no existing City improvements to transition to.	Arlen Arnold - TCC;	Accepted as Noted			No
TACMP Comment						
1-27	NA	Arlen Arnold	Accepted as Noted			No
TACMP Comment						
1-30	We are looking at the use of the islands as storm retention areas with weeps in the curb from the parking area. TACMP Comment: Only known alternate for sustainability	Arlen Arnold	Accepted as Noted			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
	is a permeable asphalt. This would cost more.					
TACMP Comment						
1-31	A pedestrian experience into a secure vehicle storage lot is not part of the remote site design. The expectation of same is reserved for the main campus.	Arlen Arnold	Accepted as Noted			No
TACMP Comment						
1-32	This information will be taken into consideration prior to finalizing planting list for the remote site and for the main site. As a rule, this tree does not leak sap. The problem occurs when the tree is in a weakened condition and becomes infested with aphids. It is the aphid that actually excreets the sap from the tree. If the tree is maintained in a healthy condition, sapping should not be a problem. DGS Comment: HLA will provide recommendations for other type of acceptable trees.	Arlen Arnold	Req'd Prior to Acceptance			No
TACMP Comment						
1-37	See previous comments	Arlen Arnold	Accepted as Noted			No
TACMP Comment						
1-39	See previous comments	Arlen Arnold	Closed			No
TACMP Comment						
1-42	See previous comments	Arlen Arnold	Accepted as Noted			No
TACMP Comment						
1-43	See previous comments. If you are directing the use of lighting in all four corners in addition to what lighting our photometric study shows our design to have, then we will provide a cost estimate upon your request for same. DGS Comment: No pricing proposal is requested. Locate the camera to avoid conflict with growing trees.	Arlen Arnold	Accepted as Noted			No

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
Old Business						
TACMP Comment						
1-45	This would be a City issue between City and DGS/Caltrans-Not a Turner design issue.	Arlen Arnold	Accepted as Noted			No
TACMP Comment						
1-48	Noted. Landscape and irrigation design will consider.	Arlen Arnold	Accepted as Noted			No
TACMP Comment						
1-49	Confirmed	Arlen Arnold	Accepted as Noted			No

Caltrans District 3 Building Replacement

625 Q Street Sacramento California 95814

Systems Confirmation-HVAC/

Date and Time: Tuesday, September 26, 2006 at 2:00 PM

Aug-06						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Sep-06						
S	M	T	W	T	F	S
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3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Oct-06						
S	M	T	W	T	F	S
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8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

Attended By

Erik Kolderup - Architectural Energy Corporation
Glenn Yee - California Transportation Dept
Ken Adams - Jacobs Facilities Inc.
Linda Matsumoto - California Transportation Dept
Lowell Shields - Capital Engineering Consultants, Inc.
Mark Chase - Jacobs Facilities Inc.
Richard Myren - Department of General Services
Steve Schultz - Turner Construction Company
Toby Leitch - Turner Construction Company
William Finney - RMW Architecture and Interiors

Non-Attendees

Item	*Meeting Item Description*	*Resp*	*Status*	*Due Date*	*Compl'd*

CLOSED ITEMS

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd
CLOSED ITEMS					
002-027	Architectural Energy Corporation (AEC) is serving as commissioning authority for this project on behalf of DGS and under contract with the CEC. Per Part 3, Section 7 “Building Commissioning” in the Design Guidelines the commissioning authority performs a design review at several stages: schematic design, design development, 50% construction documents, and 95% construction documents. This memo lists AEC’s comments based on the following: • Turner’s September 21, 2006 “systems confirmation” submittal • Presentation by Turner and design/build team members at a September 26, 2006 meeting • (AEC did not receive plans or specs to accompany the submittal narrative) Please note that this review focuses on energy performance and is not comprehensive for compliance with the overall Design Guidelines and Performance Criteria. As a general comment, it appears that the contractor is doing a good job of developing an energy efficient design and performing early energy modeling analysis to inform the design. This review is limited to the information provided to RMW by the Design Builder and is based on the conformance of the information given to the approved schematic design, the design guidelines, conceptual drawings, performance criteria and all addendums included in the Request For Proposal documents. The Design Builder remains responsible for determining the accuracy and completeness of the submittals and for substantiating the performance of equipment or systems. Comments on the systems confirmation submittals during this review do not relieve the Design Builder of its responsibility to comply with the requirements of the Proposal Documents. SEE COMMENTS NOTED ADDITIONAL SUBMITALLS REQUIRED Review of Systems Confirmation – HVAC/Plumbing of submittal package dated September 21, 2006 includes the following documents: Plumbing Systems Narrative, including specs HVAC Systems Narrative, including specs Plumbing Drawings: P-001, P-201 thru P-206 Also provided, as background information for this submittal, are the following documents: Architectural Plans (includes the reconfigured floor plates) D50 Electrical Plans Sustainable Design (LEED) Update	Mark Chase - JFI			

Item	*Meeting Item Description*	*Resp*	*Status*	*Due Date*	*Compl'd*
CLOSED ITEMS					
	Energy Modeling Life Cycle Cost (includes value added/value engineering items for consideration)				

Item	*Meeting Item Description*	*Resp*	*Status*	*Due Date*	*Compl'd*
OPEN ITEMS					
001-001	The system described in the “Core HVAC Systems” section is reasonable and appropriate.	Erik Kolderup - AEC;	Approved as Noted		
001-002	The submittal describes 35% prefilters and 85% final filters, as called for in the RFP, but the design/build team should consider MERV 13 final filters to help achieve LEED indoor environmental quality credits.	Erik Kolderup - AEC;	Design/Development		
001-003	What is the minimum pressure at which the fabric ducts can operate while still maintaining good air distribution (e.g. no dumping)? The submittal mentions that they operate at 0.5 in. w.c. If this is higher than a comparable sheet-metal duct, then are the potential savings due to static pressure reset control going to be lower with the fabric ducts? Presumably, the pressure upstream of the VAV boxes should be able to drop as low 0.5 in. during low-load periods with static pressure reset controls, and the pressure in the fabric ducts would be lower.	Erik Kolderup - AEC;	Design/Development		
001-004	Consideration should be given to separate evaporative cooling of makeup air for the kitchen rather than using mechanically cooled air.The RFP states, “Provide for energy-efficient makeup air system” (24.C.6.f.3). However, if evaporative cooling is used for makeup air, it must be confirmed that adequate comfort conditions can be maintained in the kitchen. It is possible that mechanical cooling may be required to supplement evaporative cooling. There are good guidelines on kitchen ventilation available at www.energydesignresources.com/resource/184/, and www.fishnick.com/ckv/designguide.	Erik Kolderup - AEC;	Design/Development		
001-005	Minor detail: statement regarding 100,000 hour lamp life appears to be a mistake.	Erik Kolderup - AEC;	Design/Development		
001-006	Carbon Dioxide Sensing. The submittal states that CO2 will be sensed at the return of each air handling unit to control outside air. Please note that sensing within the individual spaces is likely necessary to achieve LEED credits and meet Title 24 requirements for high occupancy spaces.	Erik Kolderup - AEC;	Design/Development		
001-007	System Right Sizing. We agree that avoiding oversizing of cooling compressors and VAV boxes can improve energy performance. However, other forms of oversizing can improve performance, such as larger air handler dimensions (filter and coil face area), air shafts, air ducts, and pipes.	Erik Kolderup - AEC;	Design/Development		

Item	*Meeting Item Description*	*Resp*	*Status*	*Due Date*	*Compl'd*
OPEN ITEMS					
001-008	Green Power. The State should be aware that the contractor is assuming the State will pay for green power certificates to earn LEED credits. However, this is not a very large investment.	Erik Kolderup - AEC;	Design/Development		
001-009	The submittal describes a proposed goal of 20% energy savings below Title 24-2005. However, the RFP lists a goal of 25%, and the contractor's proposal included a LEED scorecard indicating 5 credits for energy performance, equal to at least 24.5% savings. The concern here is that there could be a "slippage" of the performance target. If the contractor proposes to change the goal, the change should be highlighted and the reasons for the change should be made clear to the State.	Erik Kolderup - AEC;	Design/Development		
001-010	Some of the measures listed as "further enhancements (to baseline designs) were also listed in the RFP Design Guidelines (24.C.8) as design features for the contractor to consider in meeting the 25% energy savings goal. Therefore, it seems that they should not necessarily be presented as additional cost items if they are necessary to meet the overall performance goal listed in the RFP. This comment applies to daylight harvesting system, reduced friction loss in ducts and pipes, and pre-cooling outside air.	Erik Kolderup - AEC;	Design/Development		
001-011	Automatic daylighting controls with dimming ballasts were included in the contractor's original submission (Section E Sustainable Design Enhancements). Therefore, it seems inappropriate to include them in this submission as a potential extra cost item.	Erik Kolderup - AEC;	Design/Development		
001-012	Comfort in perimeter zones. The contractor should confirm that occupant comfort will be maintained in perimeter zones. One issue of potential concern is radiant temperature of the uninsulated concrete columns and beams. Another potential concern is the depth of the perimeter zone served by the fabric duct system and the fact that extra heating or cooling might be needed near the exterior wall relative to space more than 15 feet from the exterior wall.	Erik Kolderup - AEC;	Design/Development		
001-013	Comfort and air quality in spaces near the "canyon". Contractor should confirm that adequate ventilation air and comfortable air temperature will be maintained in workstations close to the open core.	Erik Kolderup - AEC;	Design/Development		
001-014	In a future submittal, contractor should provide details of building pressure control scheme that accounts for the impact of the open "canyon" space.	Erik Kolderup - AEC;	Design/Development		
001-015	Alternatives to R-22 refrigerant should be considered.	Erik Kolderup - AEC;	Design/Development		

Item	*Meeting Item Description*	*Resp*	*Status*	*Due Date*	*Compl'd*
OPEN ITEMS					
001-016	Contractor should work with Caltrans to determine requirements for off-hour control capability and to maximize the HVAC and lighting system capability to shut off service to the majority of the building while serving only occupied portions.	Erik Kolderup - AEC;	Design/Development		
001-017	Data center airside economizer and related alternatives seem worthy of further study. Caltrans information technology personnel should be consulted for their requirements.	Erik Kolderup - AEC;	Design/Development		
002-001	1. The narrative stated that hot water recirculation would not be incorporated, but in the meeting they clarified that they have changed the approach and recirculation will be incorporated.	William Finney - RMW;	Design/Development		
002-002	2. They indicated that the domestic water booster would be housed in small utility building adjacent the main building.	William Finney - RMW;	Design/Development		
002-003	3. There was considerable discussion regarding rainwater leaders and roof drains/overflows. The criteria limited the amount of roof area served by an individual drain. The Architect also restricted the use of scupper type overflows. The combination of these two items created numerous vertical piping drops within the building that are exposed per the architectural approach. We stated that we would be willing to recommend the State relax the area limitation pursuant to a layout which could demonstrate positive drainage. We also expressed concern over noise from rainwater leaders exposed within the occupied space. The Design/Builder was going to have their team's acoustical consultant review and advise.	William Finney - RMW;	Design/Development		
002-004	4. We asked that the Design/Builder submit documentation regarding the requirement of solar or renewable energy water heating was not cost effective.	William Finney - RMW;	Design/Development		
002-005	5. We questioned if the State had any issues/concerns with the use of waterless urinals or if they had any procurement issues with the proprietary chemicals for cleaning, sanitizing and operating the urinals. The response was generally acceptable, however the Design/Builder agreed to review the LEEDTM point count to see if elimination of the waterless urinals would jeopardize their LEED certification level.	William Finney - RMW;	Design/Development		
002-006	6. Segregation valves were discussed and the Design/Builder noted that each toilet core was valved separately.	William Finney - RMW;	Design/Development		
002-007	7. Wet-columns were discussed and the Design/Builder agreed to re-look at their layouts so there were no significant portions of the facility that were unreachable with water and waste.	William Finney - RMW;	Design/Development		

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd
OPEN ITEMS					
002-008	 The units are very long and relatively tall. When they extend in the direction of the roof slope, they start with a five foot curb height and get further off the roof surface and thus are inaccessible without service catwalks or rolling platforms with stair or ladders, all in conformance with OSHA. ACCO agreed to review and come back with a proposed solution to address.  The units are foreign made, but likely use mostly domestic parts. ACCO agreed to provide a parts list for the State so they could validate that critical parts would be readily available/serviceable.  We requested clarification of the refrigerant type on the unit. ACCO responded that it was R-22, but they agreed to find out if the manufacturer offered alternate refrigerants and what the additional cost would be.	William Finney - RMW;	Design/Development		
002-009	2. ACCO brought up the concern that the units were likely oversized due to the prescriptive criteria relative to internal loads and required oversizing. They agreed to provide some data to allow the State to evaluate whether the criteria should be relaxed. Apparently some field data is also being gathered from one or more of Caltrans' existing facilities.	William Finney - RMW;	Design/Development		
002-010	3. We asked what type of water treatment was planned for the cooling towers. ACCO responded that it was conventional chemical treatment.	William Finney - RMW;	Design/Development		
002-011	4. We discussed the use of the fabric ductwork and ACCO agreed to get an installation reference list for the State on similar applications. We expressed the concern that the exterior zone may have the need for more air than an interior space yet most of the runs cover both spaces. ACCO was going to research whether this is an issue and how it might be addressed. We also talked a little bit about the acoustical concerns. On one aspect, diffuser noise, the fabric duct is very positive, but does not mitigate duct born noise well, so it wouldn't be able to attenuate the VAV box noise very well. They were going to discuss with the acoustical consultant. Also, please note cleaning requirements and provisions for such.	William Finney - RMW;	Design/Development		
002-012	5. We asked about the BMS system and were told their selection has not been finalized yet.	William Finney - RMW;	Design/Development		
002-013	6. We briefly discussed zoning and it was apparent that significant differences still exist between the architectural plans and the mechanical so it would be prudent to differ that review until later.	William Finney - RMW;	Design/Development		
002-014	7. We requested the Design/Builder address the access and 'walk-overs' for the significant amount of outdoor piping and equipment on the roof.	William Finney - RMW;	Design/Development		

Item	*Meeting Item Description*	*Resp*	*Status*	*Due Date*	*Compl'd*
OPEN ITEMS					
002-015	8. The RFP criteria requires some measure of reliability/redundancy in the main HVAC system so that if a big central unit goes down, then major expanses of the building are not down and have no conditioning. The use of four air handling units satisfies that criteria	William Finney - RMW;	Design/Development		
002-016	9. Eric raised a question at the end of the discussion as to whether the distribution approach addresses the 'gridding' or 'looping' called for in the criteria. The DB replied that they have not included that and did not provide an explanation, however it appeared it was somewhat self evident from the approach of locating the VAV terminal close to the core for architectural/acoustical reasons and is tied to the approach of utilizing fabric duct for the final distribution. The looping philosophy is important with large expanses of tenant space that could be sub-zoned in the future to facilitate the introduction of additional zone terminals. It appears the architectural layout doesn't lend itself to that need, however we will keep attention to that point during the detailed distribution review.	William Finney - RMW;	Design/Development		
002-017	10. Richard Myren brought up two main issues for him, one being the 'canyon' heat migration and the other being the uninsulated concrete wall. In a short discussion, it was thought that pressurization relief through this space would be adequate to prevent stack effect and stratification problem. We will await ACCO's proposed solution for this and will comment further at that time. The un-insulated concrete however is a bigger concern. Glumac, the energy consultant for Turner, agreed to address through a load simulation analysis and report back.	William Finney - RMW;	Design/Development		
002-018	Data Center and IT closed economizer- CECI agreed to draft a memo to be forwarded to Caltrans IT for review and comment. b. Pre-cooling outside air at the four main units using the condenser water system-ACCO to work with Glumac to analyze, price and LCCA.	William Finney - RMW;	Design/Development		
002-019		William Finney - RMW;	Design/Development		
002-020	1. The fire/smoke damper schedule notes Ruskin FSD-36 although ACCO confirmed in the meeting that they would also be using some FSD-60. 2. Under the Pump schedule, the proposed pumps listed are end-suction centrifugal type, which according the criteria may only be used for flow rates below 500 gpm, however we will entertain the alternative pursuant to a suitable comparison of benefits to the State for acceptance of the alternate pump type.	William Finney - RMW;	Design/Development		

Item	*Meeting Item Description*	*Resp*	*Status*	*Due Date*	*Compl'd*
OPEN ITEMS					
002-021	1. The piping material schedule deviates from the performance specifications in the use of “M” copper for above grade domestic hot and cold water. Only “L” is allowed by the criteria. 2. The pipe hanger schedule deviates from the performance specifications in the rod size requirements for cast iron piping.	William Finney - RMW;	Design/Development		
002-022	In future submissions, note the roof area served by each drain.	William Finney - RMW;	Design/Development		
002-023	1. Regarding hose bibb’s, they must facilitate access to all areas with a 50 ft. maximum hose. 2. The grease traps must comply with local health department regulations.	William Finney - RMW;	Design/Development		
002-024	1. Tabs1 and 3-11- No comments 2. Tab 2- Architect would prefer an under-counter mounted fixture in lieu of countertop self-rimming style. 3. Tab 12- The criteria requires a triplex pressure booster station; a duplex has been proposed. 4. Tabs 13-14- No comments	William Finney - RMW;	Design/Development		
002-025	Tab 1- Comments addressed in meeting notes. 2. Tab 2- No comments 3. Tab 3- Edits appear acceptable. 4. Tab 4- Defer review pending acceptance of approach. 5. Tab 5- Review above.	William Finney - RMW;	Design/Development		
002-026	Overall, the design appears to address the major components of the revised HVAC systems criteria (Chapter 24R) and the plumbing systems criteria (Chapter 23) as well as the specifications although this was not an exhaustive review. All system sizing and equipment selections are subject to review of the calculations. Unless noted above as an exception to the criteria, the written criteria still stands and as the design evolves further we will review accordingly.	William Finney - RMW;	Design/Development		

The above notes document our understanding of items discussed in the above referenced meeting. Unless notice to the contrary is received, the notations will be considered acceptable and work will proceed based on these understandings. Any discrepancies should be brought to our attention within seven (7) working days of receipt.

Meeting Minutes

Detailed (Editable), Grouped by Each Meeting and by 'Old Business' and 'New Business'

Caltrans District 3 Building Replacement
703 "B" Street
Marysville, CA

Project # W.O.114126
Tel: Fax:

Jacobs Facilities Inc.

Systems Review-Elevator Meeting 2

Date	Start	End	Next Meeting	Next Time	Prepared By	Company
9/7/2006	08:30 AM	11:00 AM			Mark Chase	Jacobs Facilities Inc.

Purpose	Location	Next Location	General Notes
Review elevator car submittal information	Zig 3-300	Zig 3-300	

Attended By	Non-Attendees
Jacobs Facilities Inc. - Mark Chase	
Jacobs Facilities Inc. - Ken Adams	
Department of General Services - Burton Shanoff	
MHM - John Mullen	
Turner Construction Company - Arlen Arnold	
Turner Construction Company - Toby Leitch	
Turner Construction Company - Steve Schultz	
California Transportation Dept - Frank Maskovich	
California Transportation Dept - Glenn Yee	
Department of General Services - Wes Hubbart	
AC Martin Partners, Inc. - Cary McLeod	

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
Passenger Elevators						
001-001	A. Cab height is not shown, however, “overhead” listed will not accommodate the specified 108-inch high cab. B. There are no finished wall panels included in this outline. C. Flat tubular handrail is shown, and 1½-inch diameter round handrail is specified. D. Sill material shown is aluminum, and nickel-silver is specified. E. 7’high doors are shown, and 8’ door heights are specified. F. In-car directional lanterns are called for; however, hall lanterns are specified.	Al Williams - EWC;	Req'd Prior to Acceptance			No
Elevator Requirements						

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
001-002	A. Item 1: There are no provisions for card reader access. Specifications call for this to be a part of the elevator system. B. Item 4: A lobby security station has not been included. Caltrans to confirm whether this item is required. C. Item 5: Required cabling for CCTV should be a part of the elevator installation; cabling to run from each elevator car top, to the elevator machine room. D. Item 6: Dual car control panels for the three passenger elevators should be provided. E. Item 7: This item notes there are no finished car interiors.	Al Williams - EWC;	Accepted as Noted			No
Elevator System Comments						
001-003	A. It is assumed this submittal is for general compliance with the design criteria, and that a full shop drawing submittal will be made for all items being provided.	Al Williams - EWC;	Req'd Prior to Acceptance			No
Elevator Electrical						
001-006	A. Submittal data indicates that the proposed power supply voltage is 208 volts. This may be inconsistent with the anticipated building service voltage of 480 volts. Contractor shall coordinate power supply voltage requirements.	Leonard King - TEE;	Req'd Prior to Acceptance			No
Elevator Fire Protection						
001-007	B. Coordinate firefighters' phone requirements with the fire life safety design. At a minimum, provide conductors in the traveling cable for firefighters' communication service. Reference Specification Section 142100-2.8 (E).	Leonard King - TEE;	Req'd Prior to Acceptance			No
Elevator Security						
001-008	Coordinate security system card reader requirements. At a minimum, provide conductors in the traveling cable for security systems interconnections. Reference Specification Section 142100-2.3(E).	Leonard King - TEE;	Req'd Prior to Acceptance			No
Elevator Finishes						
002-001	Section 142100-2.8A.10.i and2.8A.11.g indicate nickel silver door sills. Aluminum sills should not be used.	Wes Hubbart - DGS;	Req'd Prior to Acceptance			Yes

Meeting Minutes
Detailed (Editable), Grouped by Each Meeting and by 'Old Business' and 'New Business'

Item	Meeting Item Description	Resp	Status	Due Date	Compl'd	Cls'd
New Business						
LEED						
002-002	Can machine-less elevators qualify for LEED credits due to engergy savings costs?	Wes Hubbart - DGS;	Accepted as Noted			Yes
Elevator Penthouse						
002-003	The elevator penthouse is currently not shown on plan elevations. This will be added in future plan drawings.	Cary McLeod - ACMP;	Accepted as Noted			No
Elevator Security						
002-004	Caltrans would like to have flexibility to add a card reader to the elevators at a later date.	Glenn Yee - CALTRANS;	Deferred to CD's			No

Attachments submitted by T+ACMP

GLUMAC
engineers for a sustainable future™

MEETING AGENDA

To: Carey Mcleod
AC Martin Partners

From: Erik Ring

rfc:
cc:

Project: CalTrans District 3 Headquarters
Marysville CA

Mail Original "

Project #: 906100
Subject: LEED-NC Certification Working Session

Meeting Date/Time: **Friday 2/9/06**
8:00 am to 3:00 pm

Meeting Location: CalTrans Marysville Job Site

DISTRIBUTION:

Name	Firm	Name	Firm
Steve Schultz	Turner	D Anderson	ACCO
Abou Idrissi	Turner	J Blake	Helix
Doug Gearman	Turner	I Altman	Helix
Toby Leitch	Turner	Michael Levitt	LPG Engineering
William Northrup	Turner	Erik Kolderup	AEC
Arlen Arnold	Turner	Erik Ring	Glumac
David Freedman	ACMP	Steve Strauss	Glumac
Carey McLeod	ACMP	Reid Appel	Glumac
George vanGilluwe	ACMP		

Item #	Time	Action Req'd	Due Date	Issues/Actions
1	8:00 am	Turner ACMP Glumac		**Project & LEED Status Update**
2	8:30 am	Turner ACMP Glumac		**Site Management LEED Issues** 4 Erosion Control (SSp1) 4 Construction Waste Mgmt (MRc2) 4 Construction IAQ Mgmt (EQc3, EQc4)
3	9:30 am	Turner ACMP Glumac		**Materials Sourcing Issues** 4 Recycled Content (MRc4) 4 Local/Regional Materials (MRc5) 4 FSC Certified Wood (MRc7)
4	11:00 am			**Working Lunch**

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Item #	Time	Action Req'd	Due Date	Issues/Actions
5	Noon	Turner ACMP Glumac ACCO Helix LPG AEC		**MEP LEED Issues** 4 Site Lighting (SSc8) 4 Plumbing Fixtures (WEc3) 4 Commissioning (EAp1, EAc3) 4 Measurement & Verification (EAc5) 4 Ventilation Rate (EQp1, EQc1, EQc2) 4 Construction IAQ Mgmt (Recap) 4 Indoor Pollutant Source Control (EQc5) 4 Thermal Comfort (EQc7)
6	1:30 pm	Turner ACMP Glumac		**Design Phase LEED Submittals** 4 Site Selection (SSc1) 4 Development Density (SSc2) 4 Alternative Transportation (SSc4.1, SSc4.2, SSc4.3, SSc4.4) 4 Landscaping (WEc1.1) 4 Water Use (WEc3) 4 Min. Energy Performance (EAp2) 4 Refrigerants (EAp3) 4 Optimize Energy Performance (EAc1) 4 Recyclables (MRp1) 4 Min IAQ Performance (EQp1) 4 Smoking (EQp2) 4 OSA Monitoring (EQc1) 4 Increased Ventilation (EQc2) 4 Indoor Pollutant Control (EQc5) 4 Lighting Controls (EQc6.1) 4 Thermal Comfort Design (EQc7.1) 4 Thermal Comfort Survey (EQc7.2) 4 Innovation Points (IDc1.1) 4 LEED AP (IDc2)
7	3:00 pm			**Adjourn**

Marysville Office Building Replacement Project
Department of Transportation - District 3

Meeting Minutes:
Space Program Design Meetings

July 17 and 18, 2006

Attendees (General): Day 1

Richard Myren (RM)	Department of General Services	RM
Ken Adams (KA)	Jacobs Facilities	KA
Mark Chase (MC)	Jacobs Facilities	MC
Linda Matsumoto	Caltrans District 3	LM
Frank Maskovich	Caltrans District 3	FM
Selena Kubota	Caltrans Headquarters	SK
Steve Schultz	Turner Construction	SS
Jamie Myer	AC Martin Partners	JM
Jan Von Hausen	CNI Design	JV
Clara Igonda	CNI Degign	CI
Jo Carmen	CNI Design	JC
Charlotte Mattocks	Caltrans District 3	CM

Attendees (General): Day 2

Richard Myren (RM)	Department of General Services	RM
Ken Adams (KA)	Jacobs Facilities	KA
Mark Chase (MC)	Jacobs Facilities	MC
Linda Matsumoto	Caltrans District 3	LM
Frank Maskovich	Caltrans District 3	FM
Selena Kubota	Caltrans	SK
Jamie Myer	AC Martin Partners	JM
Jan Von Hausen	CNI Design	JV
Clara Igonda	CNI Degign	CI
Jo Carmen	CNI Design	JC
Charlotte Mattocks	Caltrans District 3	CM

Department Attendees are denoted in their respective presentation sections

Resp	Description	Status
	Meeting Opening: **Project Overview and Space Program Criteria** **Meeting Agenda by AC Martin Partners: Attached** **Meeting Agenda by Caltrans Dist 3: Attached** **Typical Managers and Staff Cubicle design: Attached** **Sign In Sheets: Attached**	**All items are open and meant to provide information to be used in Future Space Planning unless otherwise noted.**

	Environmental: **John Webb** **Tammy Massengale** **Katrina Pierce**	
	1. CNI Design-Program Validation Questionnaire	**Attachment**
	2. Bio-Lab should be close to staff, used by multiple departments.	
	3. Designers should all be together	
	4. Supplies, storage area for field work-put on first floor, each division has 300sf of storage	
	5. Common file storage room can use high density files to maximize efficiency. a. Selena recommends not using first floor, should make files available on each floor.	
	6. Mail room should be on first floor	
	7. Reproduction shop should be on 3rd floor	
	8. Should have outer offices looking out windows, inner offices looking towards atrium	
	9. 2 constraints for Space Program a. Program Project Management is center of bldg to have equal access to all departments b. IT should be on 3rd floor	
	10. Typical work station layout-attached	
	11. Work mix involves working alone, writing reports, and some working with teams to disseminate information	
	12. Coffee, break rooms should be isolated away from work stations to avoid disruption to employees.	
	13. Resource area=plan room, job binder storage	
	14. Senior Managers will have enclosed offices, privacy walls, doors etc.	
	Information Services **Emmil Simeroth** **Pat Dilling** **Granoe A. Rudolph**	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. Operations center should be on same level as server room.	
	3. Request for at least one enclosed office for a meeting room,	

	a. request needs to be made by department with justification to deviate from standards	
	4. Server room racks will run short direction of room	
	5. Training room can be located on a floor away from the rest of the department, would prefer same floor but not necessary	
	6. Doors to training room should be wider for equipment	
	7. IT should be 3rd floor or above.	
	8. Need to verify the number of IDF closets that will be needed	
	9. Networking group typically has more than one computer on desk at a time.	
	10. Multiple or singular UPS should be determined. Will probably need multiple to avoid time delay and ensure redundancy in case of power failure.	
	11. New flat screen monitors do not need to have corner desks in cubicles. Allows more flexibility of desks. 36" desk tops in cubicles will be eliminated.	
	PPM-Program Project Management **Brenda Schimpf** **Andrew Brandt** **Amerjeet Benipal** **Gary Sidhu** .	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. PPM is the Central point of contact for all other departments	
	3. Currently the plans show the department is split between levels 3 and 5.	
	4. Should try to get them all on one floor	
	5. Team space(common room) not currently in design, could be useful. Large enough for 4-5 people is sufficient	
	6. Plan Layout Areas need to address wall layout and room layout to determine between temp or hard walls.	
	7. Paper storage for each division will be in 1st floor	

	common storage	
	8. Design team may be able to split up. Currently on 2nd floor.	
	9. Department is split between Engineering services and Design	
	10. Managers should be moved closer to the employees	
	Executive **Jody Jones**	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. Executive area off of elevators	
	3. Open area in front of executive department should be inviting, visitor friendly	
	4. Current plans do not have enough privacy	
	5. ACMP will rework some layouts to address Jody Jones' concerns	
	Executive Staff **Lorrie Uribe-DGS** **Katrina Pierce** **Joe Caputo** **John Rodrigues** **Gary Erdham** **Brenda Schempf** **Steve Kirkpatrick** **Jody Jones** **Lindy Lee**	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. What type of roof is on 3rd floor? a. Typical built up roof with gravel ballast	
	3. How many entrances? One. Several exits per fire code requirements.	
	4. Where are exit doors? All over, employees may have access thru the exit doors depending on type of security system.	
	5. One common entrance should promote a common, collegial, team area	
	6. Design of cafeteria (vendor leased) will depend on decision of BEP	
	7. Safety of entrance and worker access is a concern of	

	some employees b. May need a lockable gate at entrance.	
	8. Where will public park that are using the cafeteria? c. Parking will be on street in front of building d. City may make diagonal parking along B Street. e. Can work with city to make B Street a 2 hour parking zone.	
	9. There is currently no night security at this facility	
	10. How will different sides of building be built so that they are all comfortable? f. There will be SB70 glazing, trees, and the zoning of different finish materials will help to address this	
	11. Where are rest of stairs? g. There are the atrium stairs and the fire stairs next to the elevators.	
	12. Golden One kiosk will be temporarily relocated during construction	
	13. Each floor has 2 areas for coffee, water. Not a "break room"	
	14. A large part of the building exterior finish will be from the structural system. Very little paint or finishes that will deteriorate.	
	Design **Steve Kirkpatrick** **Mike Bauer** **Tom Wood** **Nick Zike** **John Snee**	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. 3 areas: surveys, designs, engineering services	
	3. 222 employee spaces	
	4. Should be close to environmental, right of way, traffic ops, and project management	
	5. Surveys should be on lower floor to minimize traffic impact to other departments.	
	6. ROW engineering needs to be near public counter a. 222 units, 45 will include engineering	

	services, balance will be in design	
	7. Landscape could be separated from design group	
	8. Map bins can be placed under map tables	
	9. Trying to get to 1 senior per 12 personnel, current design is 1 to11	
	10. District 7 work space layout will work well for Dist 3, this layout can be used as a standard for design and engineering services.	
	11. Half walls 42" or 48" can be used in design areas.	
	12. Standardizing work areas will be better for future expansion considerations	
	13. ROW engineering needs immediate proximity to storage	
	14. Public counter area will take care of permits and surveys	
	15. 500 sf will be sufficient for survey storage space. This will be in addition to the 300sf of common storage on the first floor.	
	16. Keep as much design services personnel on same floor as possible	
	17. Supply storage needs to accommodate bulk purchasing. Purchasing is done when the budget becomes available and a discount is realized by using the bulk purchasing.	
	18. Scanner space needs to be addressed, scanners cannot be fit into plotter room	
	Administration **Frank Maskovich**	
	1. 51 Administrators	
	2. 21 of 51 admin need to be near ground floor, prefer to have on executive floor	
	3. Information for Administrative Space Plan assessment is Attached	**Attachment**
	4. Traffic center shop can be eliminated	

	Maintenance and Operations **Joe Caputo** **Larry Schroeder** **Robert Peterson** **Jan Johnson** **David A. Gamboa**	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. Ops and Maint departments can be separated	
	3. Operations=Traffic	
	4. Traffic has responsibilities that go across several departments (ie: permits, electrical design)	
	5. Permits Public desk=2 senior positions, 10 other staff	
	6. Maintenance=8 supervisors	
	7. Signal Operations will need a antennae feed from roof. Will work with traffic monitoring equipment. Will need to have space to work on equipment.	
	8. Typ 36" door will be sufficient for signal equipt	
	9. Maint=32 (8 super+24 staff) 10. Traffic=77 (1+8+68) + 400sf census lab 11. Permits=12 (2super+10 staff) + 409sf support staff	
	12. Hi density filing does not work for traffic. Need to have access to all files at any time.	
	13. Would like to move file cabinets out into work space	
	Planning **Ben Bramer** **William Davis**	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. Planning should be close to PPM and Environmental	
	3. All of planning departmen needs to be next to PPM	
	4. Planning=41 (7 Senior+34 Support)	
	5. Lay out area needed for 10 to 1 group	
	Business Program Management-DGS **Lorrie Uribe**	

	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. Building manager, chief engineer, office tech, assistant engineer	
	3. BPM=21 ppl 1 Building Manager 1 Chief Engineer 2 engineers 1 maintenance mechanic 12 custodians 1 Groundskeeping	
	4. 1 Work room for balance of 21 workers that will be part of engineering	
	5. will need wide doors for pallet jack. Should use a double 3.0, rollup door to outside could help for large deliveries	
	6. Shop needs work bench, tools, metal working and wood working tools, exhaust hoods. Sacramento shop can be used as a model.	
	7. Square space works better than oblong or rectangular.	
	8. Hazmat lockers will be used if this storage is needed	
	9. Quiet room should be next to building managers space	
	10. 20 lockers can be divided 10 men, 10 women Lockers will have permanent use by custodians and should be marked as such or given special locks to differentiate between other lockers.	
	Construction **Jim Picard** **Kimberly Louis** **John Rodrigues**	
	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. Distribution center receives materials, distribute to other departments	
	3. Need access for UPS delivery a. Will have to access thru mail room	
	4. Hi density filing system will work for this division	
	Right of Way **Greg Lundblad** **Debbie Moreno** **Lindy Lee**	

	1. CNI Design Program Validation Questionnaire	**Attachment**
	2. Can be away from other departments, will interact with all departments, away from exec staff	
	3. 81 ppl=2 supervisor+2 supervisor +11 senior staff+ 67 staff	
	4. Some public access is needed	
	5. Some lockable storage is needed. Cameras, special equipment etc.	
	6. Can split copy rooms, extra 100 sf can go to copy rooms, split equally	
	7. Add more hi density storage to existing units	
	Close of Meeting	
	Next progress meeting July 28 Send plans to Richard for distribution	**Information**

Marysville Office Building Replacement Project
Department of Transportation - District 3

Meeting Minutes:
Project Kickoff Meeting

July 7, 2006

Attendees:

Richard Myren (RM)	Department of General Services	RM
Kevin Kaestner (KK)	Department of General Services	KK
Ken Adams (KA)	Jacobs Facilities	KA
Mark Chase (MC)	Jacobs Facilities	MC
Linda Matsumoto	Caltrans District 3	LM
Frank Maskovich	Caltrans District 3	FM
Glenn Yee	Caltrans	GY
Selena Kubota	Caltrans	SK
Steve Schultz	Turner Construction	SS
Frank Dai Zovi	Turner Construction	FD
Cary McLeod	AC Martin Partners	CM
Glenn Bauer	RMW Architecture	GB
Lorrie Uribe	Department of General Services	LU
Bob Sleppy	Department of General Services	BS

Resp	Description	Status
RM	**1) Meeting Attendee Introductions**	**Closed**
	2) Project Overview-Information	**Closed**
RM	a. Selection committee review of Turner-ACMP presentation was favorable. All members agreed to select this proposal as a acceptable team to complete the project.	**Closed**
RM	b. Decision made to pursue project based on availability of funds and volatility of market. Any further delays to project could delay project indefinitely.	**Closed**
BS	c. The TACM proposal was the only proposal that could accomplish the Stipulated Sum.	**Closed**
CM	i. Meetings with trades helped to resolve some budgeting constraints and bring proposal in at last minute.	**Closed**
CM	d. Colors and textures of finish materials shown during presentation are schematic and further choices will be available at a later date.	**Closed**
BS	e. Marysville is a small town and there is a great need to work with the neighbors and local	**Closed**

	authorities.	
BS	f. Employees will be very involved in construction process. Frank and Linda are very knowledgable and will work as a central point of contact for owner's.	**Closed**
BS	g. David Lamen is a good resource to use for permits. Contractor will need to keep in constant contact with him to expedite these.	**Info**
GY	h. Glenn Yee will provide oversight to ensure that the facility is built within the Caltrans standards. AC Martin should take the lead on the design with the input of Caltrans District 3. Most design parameters have been established and any deviations from these should be minimal.	**Closed**
RM	i. Concerned with concrete beam structure. Does not want a "infilled grid" for finished building.	**Info**
BS	j. It will be important to achieve the DVBE goals of the contract.	**Info**
RM	k. Funding is almost a sure thing. The PWB needs to approve the use of interim funding. The NTP cannot be sent until the Finance Committee has given go ahead.	**Closed**
CM	l. Will need approximately 13 weeks for systems configuration.	**Info**
MC	m. Preliminary schedule should include the owners concerns of space workshops and community meetings etc..	**Closed**
	3) Caltrans District 3 Work Shops	**Ongoing review of Caltrans employees is needed for success of project.**
FM	a. Limited Parking is major concern	**Open**
FM	i. May use reserved parking for tandem spots.	**Info**
FM	b. Overall, employees are pleased with the design	**Closed**
LM	c. There is a concern that the wood trellis at entrance will create a dark, unsecured area that could be difficult to patrol	**Open**
FM	d. Would like to have entrance located so that it is more convenient for employees. Very little street traffic goes into building	**Open**
FM	e. There is a concern about the noise transference of the work spaces due to the high ceilings and duct sock.	**Open**
FM	f. Jody Jones prefers the central hallways as opposed to placing them around the atrium.	**Info**
	4) D-B Team Presentations Review	
RM	a. Clark/KMD design was the most thorough and desirable for the reviewers.	**Closed**
RM	b. Reviewers largest objection to Turner/ACMP design was the location of the entrance.	**Open**

	Seen as a more urban design location that does not work well for this facility.	
LM	**5) Review of Space Utilization**	
LM	a. Linda Matsumoto and Frank Maskovich are very knowledgeable and good resources for determining what works best for the staff and facility of Caltrans District 3.	**Open**
LM	b. The Turner/ACMP proposal was difficult to assess the spaces due to the lack of scalable items on the plans (ie: doors, furniture)	**Info**
CM	c. Space Utilization workshops will be conducted by AC Martin with Caltrans employees	**Open, pending workshop.**
	d. First Workshop is scheduled for August 17. Location TBD.	**Open, TBD**
FM	e. Possible to place IT on top floor to take advantage of service penetrations?	**Closed**
CM	i. Will look into this. Not sure about length of cable runs and other advantages of placing on middle floor.	**CM to follow up**
FM	f. Will meet with Division Managers for Space Utilization workshops.	**Info**
LM	g. File room locations and loadings will need to be addressed to plan for future expansion and reduce the cost of structural reinforcement.	**Info**
	6) Preliminary Construction Work	
KA	a. The payment to the utilities for design will help expedite the underground utility work.	**Open**

6.0 Issues Log

Issues logs provide a summary of items found during the commissioning process, specifically during functional performance tests. Issues Log may be in a form of a Table or a memo depending on number of issues discovered and tracked. A table includes a reference number, the equipment name and location, a code for how the issue was identified, a description of the issue, a cause code, the date identified, action to be taken, date resolved, a responsibility code and a comment field. A memo contains list of all issues including a short description of each and it may contain additional information in form of attachments sometimes necessary for resolution of larger problems.

Issues Log

Project Name: **Marysville DOT Building** ***Wednesday, November 26, 2008***

No.	*Equipment*	*Description*	*Date Identified*	*Action Required*	*Expected Date Resolved*	*Responsibility*	*Notes*
1	CT-1 & 2	CT isolation control valve actuators (2 nos.) had been burnt out.	11/20/2008	Replace defective valve actuators	11/28/2008	CC	Siemens will replace all valve actuators (total 4 nos.) by 11/21.
2	AC-1, 2, 3, 4 & 5	OA dampers at min. position when AHUs in Warm-up Mode.	11/20/2008	OA dampers shall reset to 0% (fully closed) position to speed up the warm-up process		CC	BAS re-programming had been completed and verified on 11/21.
3	AC-1, 2, 3, 4 & 5	HW control valves of Petra AHUs remained in open position after the heating sequence ended.	11/20/2008	Investigate and resolve the issues		Petra, MC, CC	Petra identified that control wiring to valve actuators were not correct. Wiring problem had been fixed immediately and verified by AEC on 11/20.
4	AC-1, 2, 3, 4 & 5	Petra AHUs not always go to Warm-up Mode as commanded by Siemens BAS (under simulated conditions).	11/20/2008	Investigate and resolve the issues	12/2/2008	Petra, CC	Petra and Siemens are working out the conditions required to initiate Warm-up Mode. Warm-up sequence shall be enable whenever there is heating demand during unoccupied period per Sequence of Operation.
5	CW System - Tower Loop	Actual flow rate of primary CW pumps CWP-1, 2, & 3 were much higher than the designed values.	11/20/2008	Adjust BAS programming to reduce VFD speed instead of over-closing the balancing valves	12/2/2008	TAB, MC, CC	VFD speed of small pump CWP-3 and large pump (CWP-1 or 2) were allowed to ramp down to 32Hz and 30 Hz respectively to avoid over-cooling of the building CW loop and save energy (Siemens on 11/21).
6	CRAC-1, 2 & 3	Liebert CRAC units were controled by Liebert's high level interface. Only operation status and parameters were provded to Siemens BAS.	11/20/2008	ACCO and Siemens shall ensure continuous CRAC operation whenever the CW supply is switched over from CTs to Drycoolers	12/2/2008	MC, CC	
7	Siemens BAS	Graphical user interface was not completed.	11/20/2008	Graphical screens for VAVs, PCUs and Efs shall be added	12/2/2008	CC	
8	MUA-1	Makeup air unit was not interlocked with Kitchen exhaust (EF-7).	11/21/2008	Complete and verify the interlock wiring between MUA and KEF	12/2/2008	MC, CC	

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No.	Equipment	Description	Date Identified	Action Required	Expected Date Resolved	Responsibility	Notes
9	AC-1, 2, 3, 4 & 5	Building static pressure sensors of Petra units read +ve values instead of -ve values measured on the 1/F right next to the sensing probes.	11/25/2008	Calibrate all static pressure sensor of Petra units. Verify the speed controls of fans of Petra units manage to maintain design building static pressure in various cooling demand levels.	12/8/2008	Petra, MC, CC	It appeared that the RFs were running at min. speed but the OA intake CFM was still less than CFM discharged from the relief damper for Petra units.
10	AC-3 & 4	Petra failed due to high SA static pressure alarm.	11/25/2008	Investigate and resolve the issues	12/8/2008	Petra, MC, CC	It appeared that there were problems in the SF speed controls of Petra units.
11	CRAC-1, 2, 3	CRACs were tripped due to high compressor pressure alarm.	11/25/2008	Test and verify that both two DC CW control valves (DCV-1 & 2) can switching smoothly from Cooling Towers to Drycoolers.	12/8/2008	MC, CC	Drycooler CW control valve (DCV-2) failed to switch over to the DC position (remained in the CT position)
12	Siemens BAS	No alarm was generated when drycooler CW flow had not been confirmed after CRAC system was switching from CT to DC for more than 5 minutes.	11/25/2008	No CW water flow alarm shall be programmed for drycooler operation.	12/8/2008	CC	Piping schematic diagram shown on Liebert CRAC screen did not match that in the Mechanical Drawing.

This list details items discerned to be deficient per our understanding of the requirements of the construction documents (plan, specification, submittal, etc.) and owner intent. If any party feels that a particular deficiency is not within their scope, please describe the issue to the Commissioning Agent and/or Owner for clarification. Otherwise, please respond with details about how each issue is resolved.

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7.0 Sequences of Operation

This section describes sequences of operation for mechanical/HVAC installed at this project. Sequence of Operation determines the ability of the facility to perform in an energy-efficient manner. The importance of describing the function of the mechanical systems undergoing commissioning with detailed, comprehensive control strategies cannot be overemphasized. Topics that affect energy efficiency and should be addressed by the sequence of operation control strategies include:

- systems and equipment controlled
- system initiation
- modes of operation
- cooling heating & ventilation
- occupied periods & unoccupied periods
- set points for temperature, pressure, humidity
- set-back routines
- optimal starts
- time limited control of equipment
- override sequences
- alarm point ranges
- control vs. monitoring point descriptions

Caltrans
Sequence of Operation

Revised June 6, 2008

General Notes:

1. All control points and settings mentioned in sequences are adjustable.

Air Handling System – Rooftop Units and VAV Boxes

AC-Units (water-cooled)

The core heating, ventilating and air conditioning (HVAC) system consists of five (5) custom high-efficiency, water-cooled rooftop direct expansion (DX) units (AC units) located at the third, fourth and fifth floor roofs. The units include high efficiency refrigeration, hot water preheat coils, supply and return or relief fans with variable frequency drives (VFDs), fully integrated economizers, outside air (OSA) monitoring stations (except AC-5), direct digital (DDC) controls and air filtration. Heat is rejected from the water-cooled condenser section to the cooling towers. These units have factory-installed ACL controllers with a Bacnet MSTP interface to the Siemens BAS. All control functions are performed by the factory-installed ACL controllers except by the text in italics (performed by the Siemens BAS).

Start/Stop

The air handling unit is scheduled for automatic operation on a time of day basis for Occupied and Unoccupied modes (Siemens-BAS). Within the Unoccupied mode, the system can enter Warm-Up mode when the space temperature is below setpoint or the Cool-Down mode when the space temperature is above setpoint, scheduled to initiate 1hour and 1-half before occupied mode to meet occupied setpoints. Within the Unoccupied mode, Night Heating and Night Cooling (Siemens-BAS) are available. Night Heating is available when the space temperature from three or more VAV zones with associated AC unit drops below 61 F. Night Cooling is available when the space temperature from three or more VAV zones with associated AC unit increases above 82 F. The latest start time is the scheduled occupancy for the space.

Warm-Up

This mode is initiated by the Siemens BAS. The AC-Unit is enabled and forced into Morning Warmup. The heating water system is enabled (Siemens-BAS). The VAV boxes are set to heating mode and the VAV control dampers modulate to warm-up the space to the space day heating setpoint. Warm-Up mode ends when only two zones associated with the AC unit are 3 F or less below the space day heating setpoint (70F), or when time reaches the scheduled occupancy during the Warm-Up mode. The *VAV boxes control their own heating/cooling mode. The system is prevented from entering the Warm-Up mode during occupied hours.*

Night Cool-Down

This mode is initiated by the Siemens BAS. This mode is enabled during Unoccupied Mode when the space is warm and the outdoor air is cool enough to cool the building using only economizer. The AC-Unit is enabled and Mechanical Cooling is locked out. The VAV control dampers modulate to cool-down the space to the space cooling setpoint. Night Cool-Down mode is enabled when the average space temperature is greater than the cooldown setpoint (initially 78 Deg F) and the outside air temperature is at least 10 Deg F colder than the average space temperature. This mode ends when the average space temperature is 5 Deg less than the cooldown setpoint (initially 78 Deg F) or the outside air temperature is less

than 5 Deg F colder than the average space temperature, or when time reaches the scheduled occupancy during the Night Cool-Down mode. The system is prevented from entering the Night Cool-Down mode during occupied hours.

Occupied
This mode is initiated by the Siemens BAS. The AC-Unit is enabled.

During occupied mode, the VAV boxes control damper and the reheat coil control valves modulate to maintain the space setpoint.

Supply Air Temperature Setpoint
This setpoint is determined by the Siemens BAS. The supply temperature setpoint shall be reset from both the outdoor air temperature and the average zone temperature between the limits of 55-65 Deg F (adj.). The following matrix shall be used:

	OA Temp	*30*	*60*	*90*
Average Room Temp				
78		*59*	*57*	*55*
73		*62*	*59.5*	*57*
68		*65*	*62*	*59*

Preheat Coil Freeze Protection
The HW system is enabled if AC Unit low temperature detector trips.

Demand Control Ventilation
The minimum outside air setpoint is determined by the Siemens BAS. CO2 sensors located in high occupancy spaces detect the carbon dioxide concentration in the building. CO2 concentration shall be kept below 1,000 ppm differential relative to the ambient CO2 concentration outside by modulating the minimum outside air flow setpoint.

Unoccupied
This mode is initiated by the Siemens BAS. The AC-Unit is disabled.

Night Heating
This mode is initiated by the Siemens BAS. The AC-Unit is enabled and forced into Morning Warmup. The supply air temperature setpoint is 85 F. The heating water system is enabled (Siemens-BAS). The VAV reheat control valves modulate as required and all VAV boxes are in heating mode. The VAV control dampers modulate to warm up the space to the space night heating setpoint of 64 F. Night Heating mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 F or less below the space heating setpoint (or 61 Deg F). Night heating mode ends when only two zones associated with the AC unit are below the space night heating setpoint (64 Deg F).

Night Cooling
This mode is initiated by the Siemens BAS. The AC-Unit is enabled.
The VAV reheat control valves are closed (VAV boxes are in cooling mode). The VAV control dampers modulate to cool down the space to the space night cooling setpoint of 82 F. Night Cooling mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 F or more above the space cooling setpoint (or 85 Deg F). Night Cooling mode ends when only two zones associated with the AC unit are above the space night cooling setpoint (82 Deg F).

Unoccupied Override Switch
This mode is initiated by the Siemens BAS. Selected room thermostat sensors shall have an override switch for each AC unit. Upon activation of the override switch during unoccupied hours, The AC-Unit is enabled and the VAV boxes and reheat coil control valves serving the respective quadrant shall modulate to maintain the day space cooling and heating setpoints. VAV boxes serving other floors shall remain in night mode unless an override switch or other switch in mode occurs.

Alarms
The following alarm points are monitored by the BAS:
1. *Dirty Filter*
2. *VFD General Alarm*
3. *Supply Air Temperature Out of Range*
4. *Fan Status*

Condenser Water System

Cooling Tower and Tower Loop Pumps

This system is controlled by the Siemens BAS. Two (2) open cooling towers provide condenser water pumped through the tower loop side of the plate and frame heat exchanger by condenser water pumps with VFDs. The cooling towers are complete with vibration switches and VFDs. Additional condenser water pumps with VFDs circulate the building loop water through the plate and frame heat exchanger and the building systems, including the rooftop AC units, CRACs, and water-source heat pumps (PCUs).
This system will have a low load condition during off hours (when the AC units are off) and during the winter (when the AC units satisfy their cooling requirements with economizer operation only). Low load condenser water pumps, on both the tower loop and building loop, provide low flow when required. Since this system serves CRAC units and water-source heat pumps (PCUs) that operate 24/7/365, this system is always enabled and operation (when normal power is available).

Staging Control
There are 2 stages of cooling in the sequence. Stage 1 Cooling is for low CW loads. Stage 1 Cooling uses only the small CW pump (CWP-3) and the lead cooling tower. Stage 2 Cooling is for moderate to maximum CW loads. Stage 2 Cooling uses both large CW pumps (CWP-1 and CWP-2) and both cooling towers. The cooling tower system is staged to maintain a condenser water supply temperature to setpoint (variable - 65 to 80 deg. F). Please refer to the attached "Cooling Tower Load Sequencing" for additional details on how the equipment is sequenced to maintain the supply temperature to setpoint.
When Stage 1 is active and Stage 1 is at maximum cooling and the CW supply temperature is greater than setpoint for 5 minutes, Stage 2 cooling is started.
When Stage 2 is active and Stage 2 is at minimum cooling and the CW supply temperature is less than setpoint for 15 minutes, Stage 1 cooling is started.

Condenser Water Supply Temperature Setpoint Optimization
Cooling Towers are limited in their cooling capacity by the outdoor air wetbulb temperature. The condenser water supply temperature setpoint is optimized to provide the coldest possible CW (low limit of 65 deg. F) without wasting energy due to OA wetbulb limitations. When the outdoor air wetbulb temperature is lower than 55 Deg F, the condenser water supply temperature setpoint is 65 deg. F. As the outdoor air wetbulb temperature rises above 55 deg. F, the condenser water supply temperature setpoint is reset to be the outdoor air wetbulb temperature plus 10 deg. F (high limit of 80 deg. F).

Lead/Lag/Standby Rotation
Lead/Lag rotation of the cooling towers occurs monthly.

Alarms
The following alarm points are monitored by the BAS:
1. VFD General Alarm
2. Cooling Tower Isolation Valve end switches
3. Condenser Water high /low limit

Emergency Power Mode
Upon loss of Normal Power, CT-2 is disabled and CT-1 is allowed to operate. The control valves for CT-1 open and the control valves for CT-2 close. Cooling is switched to Stage 1.

Condenser Water Pumps (Building Loop)

(2) 50% duty variable speed Condenser Water Pumps (CWP-4, 5) and (1) low-load variable speed constant water pump (CWP-6) are arranged in parallel serving a common header. The pumps are staged and modulate in speed to maintain the building CW differential pressure to setpoint.

Building Loop Differential Pressure Control

CWP-6 is always the lead pump (used for low loads) and CWP-4 and CWP-5 alternate as Lag1 and Lag2 pumps. The building loop condenser water pump VFDs operate to maintain a differential pressure to setpoint (initially 5 psig).
CWP-6 is started and modulates in speed to maintain differential pressure to setpoint.
When CWP-6 is at 100% speed for 2 minutes, CWP-6 is stopped and the Lag1 CWP is started. The Lag1 pump modulates in speed from minimum to maximum.
When the Lag1 pump is at 100% speed for 2 minutes, the Lag2 pump is started. Both the Lag 1 and Lag2 pumps modulate at the same speed from minimum to maximum.
When the Lag1 and Lag2 pumps are less than 62% speed for 10 minutes, the Lag2 pump is stopped.
When the Lag1 pump is less than 62% speed for 10 minutes. the Lag1 pump is stopped and CWP-6 is started.

Pump Failure
If a CWP faiis to start when commanded on by the BAS, an aiarm is generated and the next pump in the sequence is started.

Isolation
Each CWP is manually isolated. A check valve located at the discharge of each pump provides back-flow prevention during non-operation.

Alarms
The following alarm points are monitored by the BAS:
1. Pump status

Emergency Power Mode
Upon loss of Normal Power, CWP-4, 5 shut down and CWP-6 continues to operate.

Hot Water System

This system is controlled by the Siemens BAS. The primary/secondary hot water system consists of three (3) boilers with integral primary pumps-including one 50% backup boiler-and two hot water secondary pumps with VFDs. The hot water system circulates secondary hot water generated by the boilers to AC Unit preheat coils and VAV hot water reheat coils.

Occupied Start/Stop (normal building hours)
The hot water system is enabled by the BAS when a request for heating is generated by four or more VAV hot water reheat coils or one or more AC unit preheat coils. The hot water system is disabled by the BAS when a request for heating is generated by two or less VAV hot water reheat coils and no AC unit preheat coils. When the hot water system is enabled, the factory mounted local controller on the lead boiler is commanded on. The local boiler controller provides local boiler control. When the primary HW supply temperature is less than 160 deg. F for 10 minutes, the lag boiler is enabled by the BAS. When the primary HW supply temperature is greater than 175 deg. F and the primary HW differential temperature is less than 10 deg. F for 20 minutes, the lag boiler is disabled by the BAS.

Unoccupied Night Heating, Warm-Up, Override Modes
Upon call for Night Heating, Morning Warm-Up, or activation of AC unit Override during unoccupied hours, the hot water system switches to normal building hour operation for the duration of the mode. With no call for Night Heating, Morning Warm-Up, nor activation of AC unit Override during unoccupied hours, the hot water system is disabled.

Boiler Failure
If the lead Boiler fails to start, an alarm is generated by the BAS. The lead boiler is locked out and the lag Boiler becomes the lead Boiler. The backup boiler becomes the lag boiler.

Hot Water Setpoint
The hot water system shall maintain 180 deg.F supply water in the primary loop. No hot water temperature reset is provided.

Lead/Lag Rotation
Lead/Lag rotation of the Boilers occurs monthly.

Alarms
The following alarm points are monitored by the BAS:
1. Boiler controller general alarm

Emergency Power Mode
Upon loss of Normal Power, The BAS disables all boilers.

Secondary Hot Water Pumps
(2) Secondary Hot Water Pumps (SHWP) are arranged in parallel serving a common header. Each pump is provided with a variable frequency drive (VFD). Hot water from the secondary hot water loop is circulated to the AC units on the roofs and VAV reheat coils on all floors.

Start/Stop (normal building hours)
The lead hot water pump (HWP-1 or HWP-2) starts at minimum speed after the hot water system is enabled. The lead hot water pump VFD modulates to maintain the differential pressure setpoint in the secondary hot water loop. When differential pressure setpoint falls below setpoint and the lead pump has been at 100% speed for 10 minutes, the lag hot water pump starts. When differential pressure setpoint is at setpoint and both pumps has been at less than 60% speed for 20 minutes, the lag hot water pump stops.

Speed Control
Pump speed is modulated by the BAS to maintain a differential pressure of 5 psi (adj.) in the secondary hot water loop.

Pump Failure
If a SHWP fails to start when commanded on by the BAS, an alarm is generated and the lag pump is started.

Lead/Lag Rotation
Lead/Lag rotation of SHWP occurs monthly.

Isolation
Each SHWP is manually isolated. A check valve located at the discharge of each pump provides back-flow prevention during non-operation.

Alarms
The following alarm points are monitored by the BAS:
1. Pump status

Emergency Power Mode
Upon loss of Normal Power, The BAS disables all pumps.

Computer Room A/C Units (CRAC)

This system is locally controlled by the Liebert system and monitored via Modbus integration to the Siemens BAS. The main computer room is located on the 5th floor and will be provided with Liebert water-cooled Deluxe System 3 units, or equal. N+1 configuration consists of three units, 15 nominal tons each. Units are complete with dual refrigeration circuits, humidifiers, seismic floor stands and DOC interface. Condenser water will be routed to each unit from the mechanical shaft risers. Ventilation will be provided by the unit AC-2 during scheduled occupancy.

Start/Stop
The factory mounted local controller switches lead and lag CRAC units. The lead CRAC unit rotation occurs every 150 hours. The factory mounted local controller located on the lead CRAC unit is enabled to start by the when the space temperature is above 69 deg. F. When one CRAC unit is in operation, the space setpoint shall be 70 deg. F. The lag CRAC unit is enabled to start when the space temperature is above 71 deg. F. When two CRAC units are in operation, the space setpoint shall be 72 deg. F. The local CRAC controller provides unit control to maintain the space temperature and humidity setpoints. Should the lead CRAC fail to start, an alarm shall be sent to the BAS system and the lag CRAC becomes the lead CRAC. The backup CRAC then becomes the lag CRAC.

Humidity Setpoint
The CRAC humidifiers shall maintain a setpoint of 45% RH.

Normal Operation
During normal operation, the building loop condenser water shall bypass the drycooler (DC) system and be directed to the CRACs. The two-way CRAC control valve shall open upon activation of the respective CRAC unit. The control valve shall shut upon CRAC unit shutdown.

Dry Cooler Operation
Upon failure of the condenser water system, the CRAC condenser water shall bypass the building loop condenser water system and be directed to the dry cooler system. Upon switch over to Dry Coolers, the CRAC units momentarily shut off to prevent high head pressure trip from the risk of losing water flow. The CRAC lead/lag operation and the CRAC control valves operate as during normal operation.

Alarms
1. If the lead CRAC unit fails to start, an alarm is generated by the BAS.
2. If the space temperature setpoint exceeds 72 deg. F for 10 minutes, an alarm is generated.
3. If the space humidity setpoint exceeds 55% RH for 10 minutes, an alarm is generated.

Emergency Power Mode
Upon loss of normal power, Lead and lag CRAC units are powered.

Dry Coolers (DC)

As an added level of redundancy, a Drycooler (DC-1, 2) system at the 4th level roof serves the CRAC units. The system will provide heat of rejection should the building cooling tower system fail or be taken off-line for major maintenance. The backup system includes two backup drycoolers, tie-ins to CW roof piping, 2 changeover valves and a central pumping package.

Start/Stop
The drycooler system is enabled when the following conditions are met:
1. The CRAC system is enabled AND
2. Both cooling towers have failed or are off OR
3. All three tower loop condenser water pumps have failed or are off OR
4. All three building loop condenser water pumps have failed or are off OR
5. The building loop condenser water exceeds 90 F for 10 minutes AND
6. One CRAC has gone off on high head or failed

Dry Cooler Operation
This mode is controlled by the Siemens BAS. Upon activation of the dry cooler system, the three way dry cooler bypass valves are switched, and condenser water for the CRACs is directed through the dry cooler system. The dry cooler pumps are activated. The dry coolers are staged to provide 120 deg. F condenser water to the CRACs by the local dry cooler controller. To return to normal operation, the system operator must reset the system. Upon system reset, the dry cooler pumps are stopped, the dry coolers are disabled, the three way dry
cooler bypass valves are switched, and condenser water for the CRACs is directed through the building loop condenser water system.

Alarms
If the lead DC unit fails to start, an alarm is generated by the BAS. The lead DC unit is locked out and the lag DC unit becomes the lead.

Emergency Power Mode
Upon loss of normal power, Dry coolers are powered for stand-by and initiate after 5-minute delay and above conditions are met.

Package Cooling Units (water-cooled)

This system is controlled by the Siemens BAS. The Package AC Units (PCU) are located on all floors above a ceiling. These units provide constant volume cooling to Data, Electrical, control and like rooms. Each PCU is equipped with a water-cooled DX cooling system.

Start/Stop
Each AC unit is enabled/disabled by the BAS. Typically, these units are always enabled.

Smoke Detector
PCU-2, 3 &13 is shut down upon detection of smoke in the supply duct. This function is not provided by the BAS.

Alarms
The following alarm points are monitored by the Siemens BAS:
1. If the space temperature setpoint is exceeded for more than 10 minutes, an alarm is generated.

Emergency Power Mode
Upon loss of Normal Power, PCU-2, 3,6,7,10,11,15,16,18,22 & 25 units continue to operate on emergency power at full speed. Remaining PCU units to shut down.

Make-up Air Unit

This system is controlled by the Siemens BAS. The MUA-Unit is located on the 3rd floor roof. Unit contains a 30% pre-filter, 2-stage gas furnace, and stainless steel heat exchanger. Unit serves compensating hood for 1st floor kitchen and interlocked with Gaylord (or equal) Control Panel & hood exhaust fan (EF-7).

Start/Stop
The supply fan in the make up air unit is enabled/disabled by the Siemens BAS.

Smoke Detector
Upon detection of smoke in the discharge of MUA-unit, an alarm is generated at the fire life-safety control panel (by others). The MUA supply fan is shut down upon alarm. A signal from the fire life-safety control panel disables the supply fan directly (by others). This function is not provided by the BAS.

Fan Speed Control
Fan speed is determined by the TAB contractor to meet 80% supply air CFM for hood exhaust air CFM.

Heating Setpoint
The gas-fired furnace shall stage to maintain a supply air temperature setpoint of 65 F.

Alarms
The following alarm points are monitored by the BAS:
1. Dirty Filter
2. Fan Status

Emergency Power Mode
Upon loss of Normal Power, MUA unit shuts down.

Exhaust Systems

General Exhaust Fans

Start/Stop
Exhaust Fan (EF-1, 2, 3, 5,10,11,13 thru 17) is enabled/disabled by the BAS.
Exhaust Fan (EF-7, 8) is enabled/disabled by kitchen hood control panel.
Exhaust Fan (EF-4, 6, 9) is enabied/disabled by a wall or door switch.
Exhaust Fan (EF-19, 20) is enabled/disabled by local wall t'stat.
Exhaust Fan (EF-12) is enabled/disabled by Fire Pump Alarm Panel.

Alarms (EF-1, 2, 3, 5,10,11,13 thru 17)
The following alarm points are monitored by the BAS:
1. Upon fan failure to start, an alarm is generated.

Emergency Power Mode
Upon loss of Normal Power, all EF are disabled.

Space Heaters

Space Heater Unit (IH) is suspended mount in the Shipping/Receiving Area. Unit is a gas fired radiant infrared heater. This control is independent of the BAS.

Start/Stop
Space heater unit is locally controlled by Line-Voltage Thermostat.

Space Setpoint
The space setpoint shall be 65 F when all doors are closed, otherwise setpoints will not be achievable.

Alarms
No alarms to the BAS are provided and this unit is not monitored by the BAS.

Emergency Power Mode
Upon loss of Normal Power, all IH units shut down.

Lighting Sequence of Operation

I. Local Dimming & Occupancy Sensors / Local Switch and occupancy Sensors

1) In restrooms, Copy rooms, Storage and small rooms where local switch and occupancy sensors are installed.

   Occupants shall manually turn on the local switch upon entering the room. Occupant sensors will sense occupancy and will keep the lights on. In the event that the room is vacated for 30 minutes, occupant sensor shall automatically turn off lights in these spaces.

2) Typical Tower office and perimeter conference rooms

   Occupants shall manually turn on the local switch upon entering the room. Occupant sensors will sense occupancy and will keep the lights on The occupant in these spaces has the ability to manually dim the lights in the room. In the event that the room is vacated for 30 minutes, occupant sensor shall automatically turn off lights in these spaces.

II. Lutron Ecosystem using Quantum Software (level 3 to level 16 – Tower floors)

*Installed from level 3 to level 16 of the tower building to control indirect lighting in the open office spaces only.

1. The Lutron Ecosystem shall be used to dim all the indirect lighting in the open office areas only. Indirect lighting in these spaces are provided with addressable Lutron ballast.

2. Occupants shall manually turn on the lights during business hours via the dimming override switch (shown as DO on plans). Each dimming override will control one quadrant of each floor.

3. Photo sensors will be installed in the daylight harvesting area (i.e. within 15' fee of the exterior glazing). Photo-sensors shall be programmed to automatically dim the lighting fixtures located within the daylit area. The photo-sensors can also be used and programmed to control four different lighting zones for the entire row of fixtures depending on the desired user's setting. By default, the sensors shall be set in order to maintain an average light level of 30 foot-candle at the work plane.

4. The system is programmable via Lutron Quantum system software and is provided with astronomical timeclock. PC where the software is installed will reside at level 3 workstation (grids T3.5 and TG) . The system shall be programmed for automatic sweep. Subject to Calstrs confirmation of the time and schedule, automatic sweep shall be programmed in the following manner:

a. Monday thru Friday – automatic sweep at 6:00 pm daily (warning flicker 10 minutes prior to sweep).
b. Weekends and Holidays – automatic sweep after 4 hours upon occupant activation of manual switch.

5. Once the system is programmed, users have the capability to dim the lights lower than what the photocell commands. However, users will not be available to raise the light intensity of the daylit harvest area nor override what the photocell commands the system.

6. During power crunch, the system can be adjusted by building management to dim the lights as low as possible for energy savings.

III. WATTSTOPPER LIGHTING RELAY PANELS

*installed at every floor on the podium and tower building.

1. The Wattstopper lighting control system (relay based) shall be used to control other areas not controlled by occupancy sensor or Lutron Ecosystem.

2. Occupants shall manually turn on the lights during business hours via low voltage override switch (shown as LV on plans). In the open office area of the tower, each low voltage override switch will control one quadrant of each floor. In areas other than the tower, low voltage override switch shall control fixtures as identified on plans.

3. The system is programmable via pc based system software and is provided with astronomical timeclock. The pc shall be located on level 3 (grids T3.5 and TG) in the same workstation adjacent to the Lutron Quantum system. The system shall be programmed for automatic sweep. Subject to Calstrs confirmation of the time and schedule, automatic sweep shall be programmed in the following manner:

a. Monday thru Friday – automatic sweep at 6:15 pm daily (warning flicker 10 minutes prior to sweep).
b. Weekends and Holidays – automatic sweep after 4 hours upon occupant activation of manual switch.

IV. Specialty – Audio visual lighting control interface (Grafik Eye Dimming System)

*installed at P2 Board of Chambers and P4 Training Room E213, E214 and E219.

1. Lutron Grafik Eye dimming panel (GP panel) shall be used and utilized at Level P2. The system is provided with astronomical timeclock. Scene selection and programming shall be coordinated with Calstrs for desired light level and functionality. See touch switches are also provided for manual "on/off" switch in the Board of Chamber, and 2 Committee Rooms. Switching and/or Scenes in the committee Rooms can function as 2 separate rooms or one individual room depending on the position of the motorized partition.

2. Lutron Grafix eye (HP-power boosters) shall be used and utilized at Level P4. Scene selection and programming shall be coordinated with Calstrs for desired light level and functionality. See touch switches are also provided for manual "on/off" switch. Occupancy sensors are provided in the training rooms in such a way that lights automatically turns off after 30 minutes of vacancy.

End of Sequence of Operation

8.0 Pre-Functional Checklists

Pre-functional Checklists (PFCs) are an essential part of installation and inspection process. CxA needs to confirm that the contractor supplied forms contain information sufficient to verify correct equipment installation. PFCs must be filled out by respective trade contractor. They are then collected and submitted to CxA by the GC. CxA reviews completed PFCs. If deficiencies are discovered they must be resolved prior to scheduling Functional Performance Tests (FPTs), which follow.

Pre-functional Checklists were commonly created by CxA, but in the project those forms were prepared by the contractors. This had been agreed by the owner's repsentative and CxA.

Tag #: VFD CWP 1

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	8-1-08
1.2 Cooling Body Fan and Dust Covers	BJS	
1.3 All Packing Material Removed	BJS	
1.4 Installation		
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F) (Do Not Mount Above Another Drive)*	BJS	
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	
1.5 Check and Tighten All Set Screws	BJS	
1.6 Accessibility For Future Serviceability	BJS	
1.7 UL Label and Nameplate Visible	BJS	
1.8 All Load Pre-Checklists Completed	BJS	
1.9 Mechanical Equipment Cleared of All Debris	BJS	

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/08
2.2 All Load Wiring Completed	MP	
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	

Tag #: VFD CWP 1

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	TT	10/1/08
2.12	Control Wiring Properly Shielded and Grounded	TT	10/1/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction		
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: **VFD CWP 2**

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	
1.3 All Packing Material Removed	BJS	
1.4 Installation		
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F) (Do Not Mount Above Another Drive)*	BJS	
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	
1.5 Check and Tighten All Set Screws	BJS	
1.6 Accessibility For Future Serviceability	BJS	
1.7 UL Label and Nameplate Visible	BJS	
1.8 All Load Pre-Checklists Completed	BJS	
1.9 Mechanical Equipment Cleared of All Debris	BJS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/08
2.2 All Load Wiring Completed	MP	
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	✓

Tag #: VFD CWP 2

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	JTV	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	JTV	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction	JTV	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD CWP 3

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	↓
1.3 All Packing Material Removed	BJS	↓
1.4 Installation		↓
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F) (Do Not Mount Above Another Drive)*	BJS	↓
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	↓
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	↓
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	↓
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	↓
1.5 Check and Tighten All Set Screws	BJS	↓
1.6 Accessibility For Future Serviceability	BJS	↓
1.7 UL Label and Nameplate Visible	BJS	↓
1.8 All Load Pre-Checklists Completed	BJS	↓
1.9 Mechanical Equipment Cleared of All Debris	BJS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/06
2.2 All Load Wiring Completed	MP	↓
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	✓

Tag #: VFD CWP 3

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	JTW	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	JTW	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction	JTW	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD CWP 4

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	↓
1.3 All Packing Material Removed	BJS	↓
1.4 Installation		↓
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F) (Do Not Mount Above Another Drive)*	BJS	↓
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	↓
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	↓
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	↓
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	↓
1.5 Check and Tighten All Set Screws	BJS	↓
1.6 Accessibility For Future Serviceability	BJS	↓
1.7 UL Label and Nameplate Visible	BJS	↓
1.8 All Load Pre-Checklists Completed	BJS	↓
1.9 Mechanical Equipment Cleared of All Debris	BJS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/20/08
2.2 All Load Wiring Completed	MP	↓
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	✓

Tag #: VFD CWP 4

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	JTB	10/1/08
2.12	Control Wiring Properly Shielded and Grounded	JTB	10/1/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction		
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD CWP 5

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BSS	8-1-08
1.2 Cooling Body Fan and Dust Covers	BSS	↓
1.3 All Packing Material Removed	BSS	↓
1.4 Installation		↓
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F) (Do Not Mount Above Another Drive)*	BSS	↓
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BSS	↓
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BSS	↓
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BSS	↓
1.4.5 Adequate Ventilation Within Room or Enclosure	BSS	↓
1.5 Check and Tighten All Set Screws	BSS	↓
1.6 Accessibility For Future Serviceability	BSS	↓
1.7 UL Label and Nameplate Visible	BSS	↓
1.8 All Load Pre-Checklists Completed	BSS	↓
1.9 Mechanical Equipment Cleared of All Debris	BSS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/08
2.2 All Load Wiring Completed	MP	↓
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	↓

Tag #: VFD CWP 5

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	JTO	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	JTO	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction	JTO	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD CWP 6

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	↓
1.3 All Packing Material Removed	BJS	↓
1.4 Installation		↓
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F) (Do Not Mount Above Another Drive)*	BJS	↓
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	↓
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	↓
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	↓
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	↓
1.5 Check and Tighten All Set Screws	BJS	↓
1.6 Accessibility For Future Serviceability	BJS	↓
1.7 UL Label and Nameplate Visible	BJS	↓
1.8 All Load Pre-Checklists Completed	BJS	↓
1.9 Mechanical Equipment Cleared of All Debris	BJS	↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/08
2.2 All Load Wiring Completed	MP	↓
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	↓

Tag #: VFD CWP 6

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	JTC	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	JTC	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction	JTC	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD HWP 1

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	
1.3 All Packing Material Removed	BJS	
1.4 Installation		
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F)* *(Do Not Mount Above Another Drive)*	BJS	
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	
1.5 Check and Tighten All Set Screws	BJS	
1.6 Accessibility For Future Serviceability	BJS	
1.7 UL Label and Nameplate Visible	BJS	
1.8 All Load Pre-Checklists Completed	BJS	
1.9 Mechanical Equipment Cleared of All Debris	BJS	

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/08
2.2 All Load Wiring Completed	MP	
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	

Tag #: VFD HWP 1

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	
2.7	Unit Properly Grounded	MP	
2.8	Accessibility to All Removable Covers	MP	
2.9	Proper Clearances Per Electrical Code	MP	
2.10	Permanent Power Available	MP	
2.11	Control System Interlocks Wired and Operational	JTF	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	JTF	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	
3.2	Proper Rotation Through Drive	MP	
3.3	Proper Rotation on By Pass	MP	
3.4	Unusual Noise or Motor Reaction	JTF	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD HWP 2

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	
1.3 All Packing Material Removed	BJS	
1.4 Installation		
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F) (Do Not Mount Above Another Drive)*	BJS	
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	
1.5 Check and Tighten All Set Screws	BJS	
1.6 Accessibility For Future Serviceability	BJS	
1.7 UL Label and Nameplate Visible	BJS	
1.8 All Load Pre-Checklists Completed	BJS	
1.9 Mechanical Equipment Cleared of All Debris	BJS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	[illegible]	9/25/08
2.2 All Load Wiring Completed	[illegible]	
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	[illegible]	
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	[illegible]	

Tag #: VFD HWP 2

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	TW	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	TW	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction	TW	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD CTF 1

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	
1.3 All Packing Material Removed	BJS	
1.4 Installation		
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F)* *(Do Not Mount Above Another Drive)*	BJS	
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	
1.5 Check and Tighten All Set Screws	BJS	
1.6 Accessibility For Future Serviceability	BJS	
1.7 UL Label and Nameplate Visible	BJS	
1.8 All Load Pre-Checklists Completed	BJS	
1.9 Mechanical Equipment Cleared of All Debris	BJS	W

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/08
2.2 All Load Wiring Completed	MP	
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	

Tag #: VFD CTF 1

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	
2.7	Unit Properly Grounded	MP	
2.8	Accessibility to All Removable Covers	MP	
2.9	Proper Clearances Per Electrical Code	MP	
2.10	Permanent Power Available	MP	
2.11	Control System Interlocks Wired and Operational	[illegible]	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	[illegible]	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	
3.2	Proper Rotation Through Drive	MP	
3.3	Proper Rotation on By Pass	MP	
3.4	Unusual Noise or Motor Reaction	[illegible]	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: VFD CTF 2

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Variable Frequency Drive and Accessories. Check all items below for damage, signs of excessive rust, or other indications of component failure. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable. Initial and date after each acceptable item inspected.*		
1.1 VFD Casing, Switches and Accessories	BJS	7/28
1.2 Cooling Body Fan and Dust Covers	BJS	↓
1.3 All Packing Material Removed	BJS	↓
1.4 Installation		↓
1.4.1 Securely Mounted on a Flat Non-Vibrating Surface *(Not in Direct Sunlight, Not on Surfaces Above 104 °F)* *(Do Not Mount Above Another Drive)*	BJS	↓
1.4.2 Acceptable Environment Per Manufacturer *(Between -40 °F and 158 °F & Less then 95%)*	BJS	↓
1.4.3 Proper Clearances Per Manufacturer's Specification *(50mm Clearance on Sides, 100mm Between Drives)*	BJS	↓
1.4.4 Clean, Corrosive Free Intake Air to the Drive	BJS	↓
1.4.5 Adequate Ventilation Within Room or Enclosure	BJS	↓
1.5 Check and Tighten All Set Screws	BJS	↓
1.6 Accessibility For Future Serviceability	BJS	↓
1.7 UL Label and Nameplate Visible	BJS	↓
1.8 All Load Pre-Checklists Completed	BJS	↓
1.9 Mechanical Equipment Cleared of All Debris	BJS	

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	9/25/08
2.2 All Load Wiring Completed	MP	↓
2.3 All Wiring Properly Sized Per Manufacturer's Specifications	MP	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire Protection	MP	↓

Tag #: VFD CTF 2

CHECKLIST ITEM

2.5	Line and Load Wiring In Separate Raceways	MP	9/25/08
2.6	Motor Cable Length Less then Manufacturer's Maximum Distance	MP	↓
2.7	Unit Properly Grounded	MP	↓
2.8	Accessibility to All Removable Covers	MP	↓
2.9	Proper Clearances Per Electrical Code	MP	↓
2.10	Permanent Power Available	MP	↓
2.11	Control System Interlocks Wired and Operational	JTC	10/01/08
2.12	Control Wiring Properly Shielded and Grounded	JTC	10/01/08

Comments and Observations: _____

3.0 Operational

3.1	Voltage Supply		
3.1.1.	Between Acceptable Limits (min. & max.)	MP	9/25/08
3.1.2.	Phase to Phase Within 2% of Average	MP	↓
3.2	Proper Rotation Through Drive	MP	↓
3.3	Proper Rotation on By Pass	MP	↓
3.4	Unusual Noise or Motor Reaction	JTC	10/01/08
3.5	Amperage Within Service Factor at 60 Hertz		

Comments and Observations: _____

Tag #: AC 1

CHECKLIST ITEM	INITIAL
1.0 *Physical Condition of the Rooftop VAV Unit and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*	
1.1 Unit Casing and Condenser Fins	D.C.
1.2 Vibration Isolation Adjusted and Installed Properly	D.C
1.3 Air Filters and Filter Frames	D.C.
1.4 Cooling Coils and Condensate Pans	BJS
1.5 Condensate Drains Piped and Properly Trapped	BJS
1.6 All Motorized or Backdraft Dampers	BJS
1.7 Heat Exchangers and Accessories	D.C.
1.8 Fan and Coil Bases	D.C
1.9 Supply Fan Motor and Bearings	D.C
1.10 All Shipping Hardware Removed	D.C.
1.11 Check and Tighten all Mechanical Set Screws	D.C
1.12 Motor and Fan Bearings Lubricated	D.C
1.13 Fans Rotates Freely by Hand	D.C
1.14 Fan Belt Tightness Adequate	D.C
1.15 Fan Belt Guards Replaced	D.C
1.16 Ensure Compressor Assembly Move Freely on Isolators	D.C.
1.17 Check All Refrigerant Piping and Accessories	D.C
1.18 Open all Refrigeration Hand Valves	D.C
1.19 Check and Tighten all Electrical Set Screws	D.C
1.20 Ductwork Properly Sealed and Insulated	D.C
1.21 Check Duct Isolation and Supports	D.C
1.22 Unit and Ductwork Cleaned of All Debris	D.C
1.23 Accessibility to All Removable Panels	D.C

Comments and Observations: NEED 4" Filters; Condensates not piped as of 7/23 (Fixed)

2.0 Electrical	
2.1 All disconnects and safeties properly installed and functional	MP
2.2 All load wiring completed	MP
2.3 Load wiring properly sized per manufacturer's specifications	MP
2.4 Fuses and/or breakers correctly sized for wire and unit protection	MP
2.5 Motor overload protection devices installed and functional	MP

Tag #: **AC 1**

CHECKLIST ITEM	**INITIAL**
2.6 Permanent power available	MP
2.7 Control power available	OTC
2.8 Unit properly grounded	MP
2.9 Control system interlocks wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	MP

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link Completed	OTC
3.3 Static Pressure Controls Operational	
3.4 Building Pressure Controls Operational	
3.5 Smoke Detectors Installed and Wired	
3.6 System Fire Smoke Damper Actuators Mounted and Functional	
3.7 Control Programming Mapped and Functional	[illegible]

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	MP
4.1.2. Phase to Phase within 2% of Average	MP
4.2 Proper Rotation	MP
4.3 Unusual Noise or Vibration	
4.4 Amperage within Service Factor Amperage	

Comments and Observations: _____

Tag #: **AC 1**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: BEN STRANIY
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: [signature]

Electrical

6.2 Name: MIKE PRICE
Company Name: HELIX ELECTRIC INC.
Role in inspection: SUPERINTENDENT
Signature: [signature]

Controls

6.3 Name: Todd OSMUN
Company Name: SIEMENS
Role in inspection: CONTROLS COMMUNICATIONS
Signature: [signature]

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: AC 2

CHECKLIST ITEM	INITIAL
1.0 *Physical Condition of the Rooftop VAV Unit and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*	
1.1 Unit Casing and Condenser Fins	BJS
1.2 Vibration Isolation Adjusted and Installed Properly	BJS
1.3 Air Filters and Filter Frames	
1.4 Cooling Coils and Condensate Pans	BJS
1.5 Condensate Drains Piped and Properly Trapped	BJS
1.6 All Motorized or Backdraft Dampers	BJS
1.7 Heat Exchangers and Accessories	BJS
1.8 Fan and Coil Bases	BJS
1.9 Supply Fan Motor and Bearings	BJS
1.10 All Shipping Hardware Removed	BJS
1.11 Check and Tighten all Mechanical Set Screws	BJS
1.12 Motor and Fan Bearings Lubricated	BJS
1.13 Fans Rotates Freely by Hand	BJS
1.14 Fan Belt Tightness Adequate	BJS
1.15 Fan Belt Guards Replaced	N/A
1.16 Ensure Compressor Assembly Move Freely on Isolators	BJS
1.17 Check All Refrigerant Piping and Accessories	BJS
1.18 Open all Refrigeration Hand Valves	BJS
1.19 Check and Tighten all Electrical Set Screws	BJS
1.20 Ductwork Properly Sealed and Insulated	BJS
1.21 Check Duct Isolation and Supports	BJS
1.22 Unit and Ductwork Cleaned of All Debris	BJS
1.23 Accessibility to All Removable Panels	BJS

Comments and Observations: Need 4" Filters, Cond Not Piped as of 7/25 (Fixed)

2.0 Electrical	
2.1 All disconnects and safeties properly installed and functional	WP
2.2 All load wiring completed	WP
2.3 Load wiring properly sized per manufacturer's specifications	WP
2.4 Fuses and/or breakers correctly sized for wire and unit protection	WP
2.5 Motor overload protection devices installed and functional	WP

Tag #: AC 2

CHECKLIST ITEM	INITIAL
2.6 Permanent power available	MP
2.7 Control power available	
2.8 Unit properly grounded	MP
2.9 Control system interlocks wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	MP

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link Completed	[illegible]
3.3 Static Pressure Controls Operational	
3.4 Building Pressure Controls Operational	
3.5 Smoke Detectors Installed and Wired	
3.6 System Fire Smoke Damper Actuators Mounted and Functional	
3.7 Control Programming Mapped and Functional	

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	MP
4.1.2. Phase to Phase within 2% of Average	MP
4.2 Proper Rotation	MP
4.3 Unusual Noise or Vibration	
4.4 Amperage within Service Factor Amperage	

Comments and Observations: _____

Tag #: **AC 2**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: Ben STRANLY
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: _____

Electrical

6.2 Name: MIKE PRICE
Company Name: HELIX ELECTRIC INC.
Role in inspection: SUPERINTENDENT
Signature: _____

Controls

6.3 Name: Todd T Osmon
Company Name: ~~[illegible]~~ SIEMENS
Role in inspection: Communication Linkage
Signature: _____

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: AC 3

CHECKLIST ITEM	INITIAL
1.0 *Physical Condition of the Rooftop VAV Unit and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*	
1.1 Unit Casing and Condenser Fins	BJS
1.2 Vibration Isolation Adjusted and Installed Properly	BJS
1.3 Air Filters and Filter Frames	
1.4 Cooling Coils and Condensate Pans	BJS
1.5 Condensate Drains Piped and Properly Trapped	BJS
1.6 All Motorized or Backdraft Dampers	BJS
1.7 Heat Exchangers and Accessories	BJS
1.8 Fan and Coil Bases	BJS
1.9 Supply Fan Motor and Bearings	BJS
1.10 All Shipping Hardware Removed	BJS
1.11 Check and Tighten all Mechanical Set Screws	BJS
1.12 Motor and Fan Bearings Lubricated	BJS
1.13 Fans Rotates Freely by Hand	BJS
1.14 Fan Belt Tightness Adequate	BJS
1.15 Fan Belt Guards Replaced	N/A
1.16 Ensure Compressor Assembly Move Freely on Isolators	BJS
1.17 Check All Refrigerant Piping and Accessories	BJS
1.18 Open all Refrigeration Hand Valves	BJS
1.19 Check and Tighten all Electrical Set Screws	BJS
1.20 Ductwork Properly Sealed and Insulated	BJS
1.21 Check Duct Isolation and Supports	BJS
1.22 Unit and Ductwork Cleaned of All Debris	BJS
1.23 Accessibility to All Removable Panels	BJS

Comments and Observations: Need 4" Filters, Cond Not piped
As of 7/23 (Fixed)

2.0 Electrical	
2.1 All disconnects and safeties properly installed and functional	MP
2.2 All load wiring completed	MP
2.3 Load wiring properly sized per manufacturer's specifications	MP
2.4 Fuses and/or breakers correctly sized for wire and unit protection	MP
2.5 Motor overload protection devices installed and functional	MP

Tag #: **AC 3**

CHECKLIST ITEM	**INITIAL**
2.6 Permanent power available	MR
2.7 Control power available	
2.8 Unit properly grounded	MR
2.9 Control system interlocks wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	MR

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link Completed	OTC
3.3 Static Pressure Controls Operational	
3.4 Building Pressure Controls Operational	
3.5 Smoke Detectors Installed and Wired	
3.6 System Fire Smoke Damper Actuators Mounted and Functional	
3.7 Control Programming Mapped and Functional	

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	MR
4.1.2. Phase to Phase within 2% of Average	MR
4.2 Proper Rotation	MR
4.3 Unusual Noise or Vibration	
4.4 Amperage within Service Factor Amperage	

Comments and Observations: _____

Tag #: **AC 3**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: BEN STRANIX
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: Ben

Electrical

6.2 Name: MIKE PRICE
Company Name: HELIX ELECTRIC INC.
Role in inspection: SUPERINTENDENT
Signature: [illegible]

Controls

6.3 Name: SIEMENS Todd T. Osmun
Company Name: SIEMENS
Role in inspection: Communications Linkage
Signature: _____

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: AC 4

CHECKLIST ITEM	**INITIAL**
1.0 *Physical Condition of the Rooftop VAV Unit and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*	
1.1 Unit Casing and Condenser Fins	BJS
1.2 Vibration Isolation Adjusted and Installed Properly	BJS
1.3 Air Filters and Filter Frames	
1.4 Cooling Coils and Condensate Pans	BJS
1.5 Condensate Drains Piped and Properly Trapped	BJS
1.6 All Motorized or Backdraft Dampers	BJS
1.7 Heat Exchangers and Accessories	BJS
1.8 Fan and Coil Bases	BJS
1.9 Supply Fan Motor and Bearings	BJS
1.10 All Shipping Hardware Removed	BJS
1.11 Check and Tighten all Mechanical Set Screws	BJS
1.12 Motor and Fan Bearings Lubricated	BJS
1.13 Fans Rotates Freely by Hand	BJS
1.14 Fan Belt Tightness Adequate	N/A
1.15 Fan Belt Guards Replaced	BJS
1.16 Ensure Compressor Assembly Move Freely on Isolators	BJS
1.17 Check All Refrigerant Piping and Accessories	BJS
1.18 Open all Refrigeration Hand Valves	BJS
1.19 Check and Tighten all Electrical Set Screws	BJS
1.20 Ductwork Properly Sealed and Insulated	BJS
1.21 Check Duct Isolation and Supports	BJS
1.22 Unit and Ductwork Cleaned of All Debris	BJS
1.23 Accessibility to All Removable Panels	BJS

Comments and Observations: Need 4" Filter; could not find (Fixed

2.0 Electrical	
2.1 All disconnects and safeties properly installed and functional	MP
2.2 All load wiring completed	MP
2.3 Load wiring properly sized per manufacturer's specifications	MP
2.4 Fuses and/or breakers correctly sized for wire and unit protection	MP
2.5 Motor overload protection devices installed and functional	MP

Tag #: **AC 4**

CHECKLIST ITEM	**INITIAL**
2.6 Permanent power available	MP
2.7 Control power available	
2.8 Unit properly grounded	MP
2.9 Control system interlocks wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	MP

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link Completed	TO
3.3 Static Pressure Controls Operational	
3.4 Building Pressure Controls Operational	
3.5 Smoke Detectors Installed and Wired	
3.6 System Fire Smoke Damper Actuators Mounted and Functional	
3.7 Control Programming Mapped and Functional	

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	MP
4.1.2. Phase to Phase within 2% of Average	MP
4.2 Proper Rotation	MP
4.3 Unusual Noise or Vibration	
4.4 Amperage within Service Factor Amperage	

Comments and Observations: _____

Tag #: **AC 4**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: BEN STRAUX
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: _____

Electrical

6.2 Name: MIKE PRICE
Company Name: HELIX ELECTRIC INC.
Role in inspection: SUPERINTENDENT
Signature: _____

Controls

6.3 Name: Todd T. Osman
Company Name: SIEMENS
Role in inspection: COMMUNICATIONS LINKAGE
Signature: _____

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: AC 5

CHECKLIST ITEM **INITIAL**

1.0 *Physical Condition of the Rooftop VAV Unit and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*

1.1	Unit Casing and Condenser Fins	BSS
1.2	Vibration Isolation Adjusted and Installed Properly	BSS
1.3	Air Filters and Filter Frames	
1.4	Cooling Coils and Condensate Pans	BSS
1.5	Condensate Drains Piped and Properly Trapped	BSS
1.6	All Motorized or Backdraft Dampers	BSS
1.7	Heat Exchangers and Accessories	BSS
1.8	Fan and Coil Bases	BSS
1.9	Supply Fan Motor and Bearings	BSS
1.10	All Shipping Hardware Removed	BSS
1.11	Check and Tighten all Mechanical Set Screws	BSS
1.12	Motor and Fan Bearings Lubricated	BSS
1.13	Fans Rotates Freely by Hand	BSS
1.14	Fan Belt Tightness Adequate	BSS
1.15	Fan Belt Guards Replaced	N/A
1.16	Ensure Compressor Assembly Move Freely on Isolators	BSS
1.17	Check All Refrigerant Piping and Accessories	BSS
1.18	Open all Refrigeration Hand Valves	BSS
1.19	Check and Tighten all Electrical Set Screws	BSS
1.20	Ductwork Properly Sealed and Insulated	BSS
1.21	Check Duct Isolation and Supports	BSS
1.22	Unit and Ductwork Cleaned of All Debris	BSS
1.23	Accessibility to All Removable Panels	BSS

Comments and Observations: Need [illegible] Not proper (Fixed)

2.0 Electrical

2.1	All disconnects and safeties properly installed and functional	MP
2.2	All load wiring completed	MP
2.3	Load wiring properly sized per manufacturer's specifications	MP
2.4	Fuses and/or breakers correctly sized for wire and unit protection	MP
2.5	Motor overload protection devices installed and functional	MP

Tag #: AC 5

CHECKLIST ITEM	INITIAL
2.6 Permanent power available	MP
2.7 Control power available	
2.8 Unit properly grounded	MP
2.9 Control system interlocks wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	MP

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link Completed	
3.3 Static Pressure Controls Operational	
3.4 Building Pressure Controls Operational	
3.5 Smoke Detectors Installed and Wired	
3.6 System Fire Smoke Damper Actuators Mounted and Functional	
3.7 Control Programming Mapped and Functional	

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	MP
4.1.2. Phase to Phase within 2% of Average	MP
4.2 Proper Rotation	MP
4.3 Unusual Noise or Vibration	
4.4 Amperage within Service Factor Amperage	

Comments and Observations: _____

Tag #: **AC 5**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: Ben Stromine
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: _____

Electrical

6.2 Name: MIKE PRICE
Company Name: HELIX ELECTRIC INC.
Role in inspection: SUPERINTENDENT
Signature: _____

Controls

6.3 Name: Todd T Osman
Company Name: SIEMENS
Role in inspection: COMMUNICATIONS LINKAGE
Signature: _____

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: CRAC 1

CHECKLIST ITEM	INITIAL
1.0 Physical Condition of Computer Room Unit and Accessories. Check all items below for damage or excessive rust. Initial each item after inspection.	BJS
1.1 Unit Casing and Base	BJS
1.2 Supply Fan Motor, Belts and Sheaves	BJS
1.3 Fan and Bearings	BJS
1.4 Air Filters and Filter Frames	BJS
1.5 Cooling Coils and Condensate Pan	BJS
1.6 Condensate Drain Piped and Properly Trapped	BJS
1.7 Heat Exchangers and Humidifiers	BJS
1.8 Vibration Isolation Adjusted and Installed Properly	BJS
1.9 DX Piping and Valves	BJS
1.10 Open all DX Hand Valves	BJS
1.11 Check and Tighten all Mechanical Set Screws	BJS
1.12 Check and Tighten all Electrical Set Screws	BJS
1.13 All Shipping Hardware Removed	BJS
1.14 Ensure Compressor Assembly Move Freely on Isolators	BJS
1.15 Fan Belts Properly Adjusted	BJS
1.16 Fans Rotates Freely by Hand	BJS
1.17 Motor and Fan Bearings Lubricated	BJS
1.18 Unit Cleaned of All Debris	BJS
1.19 Accessibility to All Removable Panels	BJS

Comments and Observations: _____

2.0 Electrical	
2.1 All Disconnects and Safeties Properly Installed and Functional	MP
2.2 All Load Wiring Completed	MP
2.3 Load Wiring Properly Sized per Manufacturer's Specifications	MP
2.4 Fuses and/or Breakers Correctly Sized for Wire and Unit Protection	MP
2.5 Motor Overload Protection Devices Installed and Functional	MP
2.6 Permanent Power Available	MP
2.7 Control Power Available	

Tag #: CRAC 1

CHECKLIST ITEM	**INITIAL**
2.8 Unit Properly Grounded	MP
2.9 Control System Interlocks Wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	MP

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link or Thermostat Completed	
3.3 Smoke Detectors Installed and Wired	
3.4 System Fire Smoke Damper Actuators Mounted and Functional	
3.5 Control Programming Mapped and Functional	

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	MP
4.1.2. Phase to Phase Within 2% of Average	MP
4.2 Proper Rotation	MP
4.3 Unusual Noise or Vibration	
4.4 Amperage Within Service Factor Amps	

Comments and Observations: _____

Tag #: **CRAC 1**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: Ben Strawing
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: _____

Electrical

6.2 Name: Mike Price
Company Name: Helix Electric Inc.
Role in inspection: Superintendent
Signature: _____

Controls

6.3 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: **CRAC 2**

CHECKLIST ITEM	**INITIAL**
1.0 Physical Condition of Computer Room Unit and Accessories. Check all items below for damage or excessive rust. Initial each item after inspection.	BJS
1.1 Unit Casing and Base	BJS
1.2 Supply Fan Motor, Belts and Sheaves	BJS
1.3 Fan and Bearings	BJS
1.4 Air Filters and Filter Frames	BJS
1.5 Cooling Coils and Condensate Pan	BJS
1.6 Condensate Drain Piped and Properly Trapped	BJS
1.7 Heat Exchangers and Humidifiers	BJS
1.8 Vibration Isolation Adjusted and Installed Properly	BJS
1.9 DX Piping and Valves	BJS
1.10 Open all DX Hand Valves	BJS
1.11 Check and Tighten all Mechanical Set Screws	BJS
1.12 Check and Tighten all Electrical Set Screws	BJS
1.13 All Shipping Hardware Removed	BJS
1.14 Ensure Compressor Assembly Move Freely on Isolators	BJS
1.15 Fan Belts Properly Adjusted	BJS
1.16 Fans Rotates Freely by Hand	BJS
1.17 Motor and Fan Bearings Lubricated	BJS
1.18 Unit Cleaned of All Debris	BJS
1.19 Accessibility to All Removable Panels	BJS

Comments and Observations: _____

2.0 Electrical	
2.1 All Disconnects and Safeties Properly Installed and Functional	WP
2.2 All Load Wiring Completed	WP
2.3 Load Wiring Properly Sized per Manufacturer's Specifications	WP
2.4 Fuses and/or Breakers Correctly Sized for Wire and Unit Protection	WP
2.5 Motor Overload Protection Devices Installed and Functional	WP
2.6 Permanent Power Available	WP
2.7 Control Power Available	

Tag #: CRAC 2

CHECKLIST ITEM	**INITIAL**
2.8 Unit Properly Grounded	MP
2.9 Control System Interlocks Wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	MP

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link or Thermostat Completed	
3.3 Smoke Detectors Installed and Wired	
3.4 System Fire Smoke Damper Actuators Mounted and Functional	
3.5 Control Programming Mapped and Functional	

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	MP
4.1.2. Phase to Phase Within 2% of Average	MP
4.2 Proper Rotation	MP
4.3 Unusual Noise or Vibration	
4.4 Amperage Within Service Factor Amps	

Comments and Observations: _____

Tag #: **CRAC 2**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: BEN STRAMIX
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: _____

Electrical

6.2 Name: MIKE PRICE
Company Name: HELIX ELECTRIC INC.
Role in inspection: SUPERINTENDENT
Signature: _____

Controls

6.3 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: CRAC 3

CHECKLIST ITEM	**INITIAL**
1.0 Physical Condition of Computer Room Unit and Accessories. Check all items below for damage or excessive rust. Initial each item after inspection.	BSS
1.1 Unit Casing and Base	BSS
1.2 Supply Fan Motor, Belts and Sheaves	BSS
1.3 Fan and Bearings	BSS
1.4 Air Filters and Filter Frames	BSS
1.5 Cooling Coils and Condensate Pan	BSS
1.6 Condensate Drain Piped and Properly Trapped	BSS
1.7 Heat Exchangers and Humidifiers	BSS
1.8 Vibration Isolation Adjusted and Installed Properly	BSS
1.9 DX Piping and Valves	BTS
1.10 Open all DX Hand Valves	BTS
1.11 Check and Tighten all Mechanical Set Screws	BTS
1.12 Check and Tighten all Electrical Set Screws	BTS
1.13 All Shipping Hardware Removed	BTS
1.14 Ensure Compressor Assembly Move Freely on Isolators	BTS
1.15 Fan Belts Properly Adjusted	BTS
1.16 Fans Rotates Freely by Hand	BTS
1.17 Motor and Fan Bearings Lubricated	BTS
1.18 Unit Cleaned of All Debris	BTS
1.19 Accessibility to All Removable Panels	BTS

Comments and Observations: _____

2.0 Electrical	
2.1 All Disconnects and Safeties Properly Installed and Functional	MB
2.2 All Load Wiring Completed	MB
2.3 Load Wiring Properly Sized per Manufacturer's Specifications	MB
2.4 Fuses and/or Breakers Correctly Sized for Wire and Unit Protection	MB
2.5 Motor Overload Protection Devices Installed and Functional	MB
2.6 Permanent Power Available	MB
2.7 Control Power Available	

Tag #: CRAC 3

CHECKLIST ITEM	**INITIAL**
2.8 Unit Properly Grounded	mp
2.9 Control System Interlocks Wired	
2.10 Visibility of Unit Labels	
2.11 Accessibility to All Removable Panels	
2.12 Proper Clearances to All Electrical Compartments and Services	mp

Comments and Observations: _____

3.0 Controls

3.1 Limits and Other External Safeties Installed and Tested	
3.2 Communication Link or Thermostat Completed	
3.3 Smoke Detectors Installed and Wired	
3.4 System Fire Smoke Damper Actuators Mounted and Functional	
3.5 Control Programming Mapped and Functional	

Comments and Observations: _____

4.0 Operational

4.1 Voltage Supply	
4.1.1. Between Acceptable Limits (min. & max.)	mp
4.1.2. Phase to Phase Within 2% of Average	mp
4.2 Proper Rotation	mp
4.3 Unusual Noise or Vibration	
4.4 Amperage Within Service Factor Amps	

Comments and Observations: _____

Tag #: **CRAC 3**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: Ben Strain
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: _____

Electrical

6.2 Name: Mike Price
Company Name: Henix Electric Inc.
Role in inspection: Superintendent
Signature: _____

Controls

6.3 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

G.C.

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Tag #: **DC 1**

CHECKLIST ITEM	**INITIAL**
1.0 Physical Condition of Cooling Tower and Piping. Check all items below for damage or excessive rust. Initial each item after inspection.	
1.1 Cooling Fan and Bearings	BJS
1.2 Cooling Fan Motor and Brackets	BJS
1.3 Belts and Sheaves	BJS
1.4 Sheet Metal Housing and Access Doors	BJS
1.14 Condenser Water Piping Completed	BJS
1.15 Fan Belt Guards	N/A
1.16 Belts Tightened and Aligned	BJS
1.17 Check and Tighten all Mechanical Set Screws	BJS
1.18 Check All Electrical Connections	BJS
1.19 Shipping Blocks Removed	BJS
1.20 Fan Rotates Freely by Hand	BJS
1.21 Motor and Fan Bearings Lubricated	BJS
1.22 Unit Cleaned of All Debris	BJS
1.23 Closed System Piping Filled	BJS
1.25 Isolation Springs Adjusted	BJS
1.26 No Water Leaks From Piping or Valves	

Comments and Observations: _____

2.0 Electrical

2.1 All Disconnects and Safeties Properly Installed and Functional	MP
2.2 All Load Wiring Completed	MP
2.3 Load Wiring Properly Sized per Manufacturer's Specifications	MP
2.4 Fuses and/or Breakers Correctly Sized for Wire and Unit Protection	MP
2.5 Motor Overload Protection Devices Installed and Functional	MP

Tag #: DC 1 **INITIAL**

CHECKLIST ITEM

2.6 Permanent Power Available
2.7 Unit Properly Grounded
2.8 Control System Interlocks Wired
2.9 Visibility of Unit Labels
2.10 Accessibility to All Removable Panels
2.11 Proper Clearances to All Electrical Compartments and Services

Comments and Observations:

3.0 Controls
3.1 Vibration Switches Wired and Checked
3.2 Temperature Controls Operational
3.3 Magnetic Starters Properly Interlocked
3.4 Slow Speed Time Delay Adjusted
3.5 ~~VFD~~ or ~~Damper~~ VALVE Controls Operational
3.6 Control Programming Mapped and Functional

Comments and Observations:

4.0 Operational
4.1 Voltage Supply
4.1.1. Between Acceptable Limits (min. & max.)
4.1.2. Phase to Phase within 2% of Average
4.2 Proper Rotation
4.3 Unusual Noise or Vibration
4.4 Amperage Within Service Factor Amperage

Comments and Observations:

Tag #: **DC 1**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

Mechanical

6.1 Name: Ben STRANIK
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: [signature]

Electrical

6.2 Name: MIKE RICE
Company Name: HELIX ELECTRIC INC.
Role in inspection: SUPERINTENDENT
Signature: [signature]

Controls

6.3 Name: Todd T. Osmon
Company Name: SIEMENS
Role in inspection: ~~WATER~~ Condenser WATER CONTROLS
Signature: [signature]

G.C.

6.4 Name:
Company Name:
Role in inspection:
Signature:

Tag #: **DC 2**

CHECKLIST ITEM	**INITIAL**
1.0 Physical Condition of Cooling Tower and Piping. Check all items below for damage or excessive rust. Initial each item after inspection.	
1.1 Cooling Fan and Bearings	BJS
1.2 Cooling Fan Motor and Brackets	BJS
1.3 Belts and Sheaves	BJS
1.4 Sheet Metal Housing and Access Doors	BJS
1.14 Condenser Water Piping Completed	BJS
1.15 Fan Belt Guards	BJS
1.16 Belts Tightened and Aligned	BJS
1.17 Check and Tighten all Mechanical Set Screws	BJS
1.18 Check All Electrical Connections	BJS
1.19 Shipping Blocks Removed	BJS
1.20 Fan Rotates Freely by Hand	BJS
1.21 Motor and Fan Bearings Lubricated	BJS
1.22 Unit Cleaned of All Debris	BJS
1.23 Closed System Piping Filled	BJS
1.25 Isolation Springs Adjusted	BJS
1.26 No Water Leaks From Piping or Valves	

Comments and Observations: _____

2.0 Electrical

2.1 All Disconnects and Safeties Properly Installed and Functional	MR
2.2 All Load Wiring Completed	MR
2.3 Load Wiring Properly Sized per Manufacturer's Specifications	MR
2.4 Fuses and/or Breakers Correctly Sized for Wire and Unit Protection	MR
2.5 Motor Overload Protection Devices Installed and Functional	MR

Tag #: DC 2 **INITIAL**

CHECKLIST ITEM

2.6 Permanent Power Available
2.7 Unit Properly Grounded
2.8 Control System Interlocks Wired
2.9 Visibility of Unit Labels
2.10 Accessibility to All Removable Panels
2.11 Proper Clearances to All Electrical Compartments and Services

Comments and Observations:

3.0 Controls
3.1 Vibration Switches Wired and Checked
3.2 Temperature Controls Operational
3.3 Magnetic Starters Properly Interlocked
3.4 Slow Speed Time Delay Adjusted
3.5 ~~VFD~~ or ~~Damper~~ Valve Controls Operational
3.6 Control Programming Mapped and Functional

Comments and Observations:

4.0 Operational
4.1 Voltage Supply
4.1.1. Between Acceptable Limits (min. & max.)
4.1.2. Phase to Phase within 2% of Average
4.2 Proper Rotation
4.3 Unusual Noise or Vibration
4.4 Amperage Within Service Factor Amperage

Comments and Observations:

Tag #: **DC 2**

5.0 Deficiencies and Corrections

Any items of non-compliance will be noted on the Deficiency Report. The Deficiency Report contains information such as date found, cause, responsibility, etc.

6.0 Certification

We the undersigned participated in this pre-functional inspection, acknowledge that the prefunctional process for the above mentioned equipment has been completed and that all corrections have been made.

Date: _____

6.1 Name: Ben Stranix
Company Name: Air Conditioning Company, Inc.
Role in inspection: Startup Technician
Signature: _____

6.2 Name: Mike Price
Company Name: Helix Electric Inc
Role in inspection: Superintendent
Signature: _____

6.3 Name: Todd Toomuw
Company Name: Siemens
Role in inspection: Condenser Valve Controls
Signature: _____

6.4 Name: _____
Company Name: _____
Role in inspection: _____
Signature: _____

Mechanical **Electrical** **Controls** **G.C.**

Tag #: **EF - 1**

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BTS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/16/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF - 1**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations: _____

Tag #: **EF 2**

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 2**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations: _____

Tag #: EF 3

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-03
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/03
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 3**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations:

Tag #: **EF 4**

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 4**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	✓	✓
3.2 Proper Rotation	✓	✓
3.3 Unusual Noise or Vibration	✓	✓
3.4 Amperage Within Service Factor	✓	✓

Comments and Observations: _____

Tag #: EF 5

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-08
1.2 Exhaust Fan Motor	↓	↓
1.3 Backdraft Dampers Move Freely	↓	↓
1.4 Vibration Isolation Units	↓	↓
1.5 Exhaust Duct Final Connections	↓	↓
1.6 Shipping Blocks Removed	↓	↓
1.7 Fan Cleared of All Debris	↓	↓
1.8 Belt Tightness and Alignment	↓	↓
1.9 Check and Tighten All Set Screws	↓	↓
1.10 Fan Rotates Freely By Hand	↓	↓
1.11 Motor and Fan Bearings Lubricated	↓	↓
1.12 Fan and Motor Ratings Meet Job Specifications	↓	↓
1.13 Protective Guards and Screens Installed	↓	↓
1.14 Proper Clearances for Serviceability	↓	↓
1.15 Ductwork Completed and Clean	↓	↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 5**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations: _____

Tag #: EF 6

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BSS	10-1-08
1.2 Exhaust Fan Motor	↓	↓
1.3 Backdraft Dampers Move Freely	↓	↓
1.4 Vibration Isolation Units	↓	↓
1.5 Exhaust Duct Final Connections	↓	↓
1.6 Shipping Blocks Removed	↓	↓
1.7 Fan Cleared of All Debris	↓	↓
1.8 Belt Tightness and Alignment	↓	↓
1.9 Check and Tighten All Set Screws	↓	↓
1.10 Fan Rotates Freely By Hand	↓	↓
1.11 Motor and Fan Bearings Lubricated	↓	↓
1.12 Fan and Motor Ratings Meet Job Specifications	↓	↓
1.13 Protective Guards and Screens Installed	↓	↓
1.14 Proper Clearances for Serviceability	↓	↓
1.15 Ductwork Completed and Clean	↓	↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/16/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 6**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations: _____

Tag #: EF 7

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-08
1.2 Exhaust Fan Motor	↓	↓
1.3 Backdraft Dampers Move Freely	↓	↓
1.4 Vibration Isolation Units	↓	↓
1.5 Exhaust Duct Final Connections	↓	↓
1.6 Shipping Blocks Removed	↓	↓
1.7 Fan Cleared of All Debris	↓	↓
1.8 Belt Tightness and Alignment	↓	↓
1.9 Check and Tighten All Set Screws	↓	↓
1.10 Fan Rotates Freely By Hand	↓	↓
1.11 Motor and Fan Bearings Lubricated	↓	↓
1.12 Fan and Motor Ratings Meet Job Specifications	↓	↓
1.13 Protective Guards and Screens Installed	↓	↓
1.14 Proper Clearances for Serviceability	↓	↓
1.15 Ductwork Completed and Clean		↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MR	10/10/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 7**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	↓	↓
3.2 Proper Rotation	↓	↓
3.3 Unusual Noise or Vibration	↓	↓
3.4 Amperage Within Service Factor	↓	↓

Comments and Observations: _____

Tag #: **EF 8**

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BSS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	—	—

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/16/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 8**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	✓	✓
3.2 Proper Rotation	✓	✓
3.3 Unusual Noise or Vibration	✓	✓
3.4 Amperage Within Service Factor	✓	✓

Comments and Observations: _____

Tag #: EF 9

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BSS	10-1-08
1.2 Exhaust Fan Motor	↓	↓
1.3 Backdraft Dampers Move Freely	↓	↓
1.4 Vibration Isolation Units	↓	↓
1.5 Exhaust Duct Final Connections	↓	↓
1.6 Shipping Blocks Removed	↓	↓
1.7 Fan Cleared of All Debris	↓	↓
1.8 Belt Tightness and Alignment	↓	↓
1.9 Check and Tighten All Set Screws	↓	↓
1.10 Fan Rotates Freely By Hand	↓	↓
1.11 Motor and Fan Bearings Lubricated	↓	↓
1.12 Fan and Motor Ratings Meet Job Specifications	↓	↓
1.13 Protective Guards and Screens Installed	↓	↓
1.14 Proper Clearances for Serviceability	↓	↓
1.15 Ductwork Completed and Clean	↓	↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/16/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 9**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	↓	↓
3.2 Proper Rotation	↓	↓
3.3 Unusual Noise or Vibration	↓	↓
3.4 Amperage Within Service Factor	↓	↓

Comments and Observations: _____

Tag #: EF 10

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 10**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations: _____

Tag #: EF 11

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BSS	10-1-08
1.2 Exhaust Fan Motor	↓	↓
1.3 Backdraft Dampers Move Freely	↓	↓
1.4 Vibration Isolation Units	↓	↓
1.5 Exhaust Duct Final Connections	↓	↓
1.6 Shipping Blocks Removed	↓	↓
1.7 Fan Cleared of All Debris	↓	↓
1.8 Belt Tightness and Alignment	↓	↓
1.9 Check and Tighten All Set Screws	↓	↓
1.10 Fan Rotates Freely By Hand	↓	↓
1.11 Motor and Fan Bearings Lubricated	↓	↓
1.12 Fan and Motor Ratings Meet Job Specifications	↓	↓
1.13 Protective Guards and Screens Installed	↓	↓
1.14 Proper Clearances for Serviceability	↓	↓
1.15 Ductwork Completed and Clean	↓	↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/12/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 11**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-14-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations: Motor is BAD. (10-14-08)

Tag #: **EF 12**

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 12**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	↓	↓
3.2 Proper Rotation	↓	↓
3.3 Unusual Noise or Vibration	↓	↓
3.4 Amperage Within Service Factor	↓	↓

Comments and Observations: _____

Tag #: EF 13

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	8/21/08
1.2 Exhaust Fan Motor	BJS	↓
1.3 Backdraft Dampers Move Freely	N/A	↓
1.4 Vibration Isolation Units	BJS	↓
1.5 Exhaust Duct Final Connections	BJS	↓
1.6 Shipping Blocks Removed	BJS	↓
1.7 Fan Cleared of All Debris	BJS	↓
1.8 Belt Tightness and Alignment	BJS	↓
1.9 Check and Tighten All Set Screws	BJS	↓
1.10 Fan Rotates Freely By Hand	BJS	↓
1.11 Motor and Fan Bearings Lubricated	BJS	↓
1.12 Fan and Motor Ratings Meet Job Specifications	BJS	↓
1.13 Protective Guards and Screens Installed	BJS	↓
1.14 Proper Clearances for Serviceability	BJS	↓
1.15 Ductwork Completed and Clean	BJS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 13**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations:

Tag #: EF 14

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	8/21/08
1.2 Exhaust Fan Motor	BJS	↓
1.3 Backdraft Dampers Move Freely	BJS	↓
1.4 Vibration Isolation Units	BJS	↓
1.5 Exhaust Duct Final Connections	BJS	↓
1.6 Shipping Blocks Removed	BJS	↓
1.7 Fan Cleared of All Debris	BJS	↓
1.8 Belt Tightness and Alignment	BJS	↓
1.9 Check and Tighten All Set Screws	BJS	↓
1.10 Fan Rotates Freely By Hand	BJS	↓
1.11 Motor and Fan Bearings Lubricated	BJS	↓
1.12 Fan and Motor Ratings Meet Job Specifications	BJS	↓
1.13 Protective Guards and Screens Installed	BJS	↓
1.14 Proper Clearances for Serviceability	BJS	↓
1.15 Ductwork Completed and Clean	BJS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/15/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 14**

CHECKLIST ITEM	INITIAL	DATE
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	↑	↑
3.2 Proper Rotation	↑	↑
3.3 Unusual Noise or Vibration	↑	↑
3.4 Amperage Within Service Factor	↑	↑

Comments and Observations: _____

Tag #: **EF 15**

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 15**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations: _____

Tag #: EF 16

CHECKLIST ITEM	INITIAL	DATE
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BS	10-1-08
1.2 Exhaust Fan Motor	↓	↓
1.3 Backdraft Dampers Move Freely	↓	↓
1.4 Vibration Isolation Units	↓	↓
1.5 Exhaust Duct Final Connections	↓	↓
1.6 Shipping Blocks Removed	↓	↓
1.7 Fan Cleared of All Debris	↓	↓
1.8 Belt Tightness and Alignment	↓	↓
1.9 Check and Tighten All Set Screws	↓	↓
1.10 Fan Rotates Freely By Hand	↓	↓
1.11 Motor and Fan Bearings Lubricated	↓	↓
1.12 Fan and Motor Ratings Meet Job Specifications	↓	↓
1.13 Protective Guards and Screens Installed	↓	↓
1.14 Proper Clearances for Serviceability	↓	↓
1.15 Ductwork Completed and Clean	↓	↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 16**

CHECKLIST ITEM	INITIAL	DATE
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations:

Tag #: **EF 17**

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	10-1-08
1.2 Exhaust Fan Motor	✓	✓
1.3 Backdraft Dampers Move Freely	✓	✓
1.4 Vibration Isolation Units	✓	✓
1.5 Exhaust Duct Final Connections	✓	✓
1.6 Shipping Blocks Removed	✓	✓
1.7 Fan Cleared of All Debris	✓	✓
1.8 Belt Tightness and Alignment	✓	✓
1.9 Check and Tighten All Set Screws	✓	✓
1.10 Fan Rotates Freely By Hand	✓	✓
1.11 Motor and Fan Bearings Lubricated	✓	✓
1.12 Fan and Motor Ratings Meet Job Specifications	✓	✓
1.13 Protective Guards and Screens Installed	✓	✓
1.14 Proper Clearances for Serviceability	✓	✓
1.15 Ductwork Completed and Clean	✓	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/10/08
2.2 All Load Wiring Completed	✓	✓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	✓	✓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	✓	✓
2.5 Motor Overload Protection Devices Installed and Functional	✓	✓
2.6 Unit Properly Grounded	✓	✓
2.7 Accessibility to All Removable Panels and Covers	✓	✓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: EF 17

CHECKLIST ITEM	INITIAL	DATE
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	✓	✓
3.2 Proper Rotation	✓	✓
3.3 Unusual Noise or Vibration	✓	✓
3.4 Amperage Within Service Factor	✓	✓

Comments and Observations: _____

Tag #: EF 19

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BJS	8/21/08
1.2 Exhaust Fan Motor	BJS	↓
1.3 Backdraft Dampers Move Freely	BJS	↓
1.4 Vibration Isolation Units	BJS	↓
1.5 Exhaust Duct Final Connections	BJS	↓
1.6 Shipping Blocks Removed	BJS	↓
1.7 Fan Cleared of All Debris	BJS	↓
1.8 Belt Tightness and Alignment	BJS	↓
1.9 Check and Tighten All Set Screws	BJS	
1.10 Fan Rotates Freely By Hand	BJS	↓
1.11 Motor and Fan Bearings Lubricated	BJS	↓
1.12 Fan and Motor Ratings Meet Job Specifications	BJS	↓
1.13 Protective Guards and Screens Installed	BJS	↓
1.14 Proper Clearances for Serviceability	BJS	↓
1.15 Ductwork Completed and Clean	BJS	↓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/16/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	↓	↓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: EF 19

CHECKLIST ITEM	INITIAL	DATE
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BSS	10-1-08
3.1.2 Phase to Phase Within 2% of Average		
3.2 Proper Rotation		
3.3 Unusual Noise or Vibration		
3.4 Amperage Within Service Factor		

Comments and Observations:

Tag #: **EF 20**

CHECKLIST ITEM	**INITIAL**	**DATE**
1.0 *Physical Condition of the Exhaust Fan and Accessories. Check all items below for damage, excessive rust, or other signs of compromised components. Complete the appropriate Deficiency Correction Form for those items found to be incomplete or unacceptable and initial after each acceptable item inspected.*		
1.1 Exhaust Fan, Fan Casing, and Bearings	BSS	8/21/08
1.2 Exhaust Fan Motor	BJS	↓
1.3 Backdraft Dampers Move Freely	BJS	↓
1.4 Vibration Isolation Units	BJS	↓
1.5 Exhaust Duct Final Connections	BJS	↓
1.6 Shipping Blocks Removed	BJS	↓
1.7 Fan Cleared of All Debris	BJS	↓
1.8 Belt Tightness and Alignment	BJS	↓
1.9 Check and Tighten All Set Screws	BJS	↓
1.10 Fan Rotates Freely By Hand	BJS	↓
1.11 Motor and Fan Bearings Lubricated	RJS	↓
1.12 Fan and Motor Ratings Meet Job Specifications	BJS	↓
1.13 Protective Guards and Screens Installed	RJS	↓
1.14 Proper Clearances for Serviceability	BJS	↓
1.15 Ductwork Completed and Clean	BJS	✓

Comments and Observations: _____

2.0 Electrical		
2.1 All Disconnects and Safeties Properly Installed and Functional	MP	10/16/08
2.2 All Load Wiring Completed	↓	↓
2.3 Load Wiring Properly Sized Per Manufacturer's Specifications	↓	↓
2.4 Fuses and/or Breakers Correctly Sized For Wire and Unit Protection	↓	↓
2.5 Motor Overload Protection Devices Installed and Functional	↓	↓
2.6 Unit Properly Grounded	↓	↓
2.7 Accessibility to All Removable Panels and Covers	↓	↓
2.8 Permanent Power Available	✓	✓
2.9 Control Power Available		
2.10 Control System Interlocks Wired and Operational		

Comments and Observations: _____

Tag #: **EF 20**

CHECKLIST ITEM	**INITIAL**	**DATE**
3.0 Operational		
3.1 Voltage Supply		
3.1.1 Between Acceptable Limits (min. & max.)	BJS	10-1-08
3.1.2 Phase to Phase Within 2% of Average	✓	✓
3.2 Proper Rotation	✓	✓
3.3 Unusual Noise or Vibration	✓	✓
3.4 Amperage Within Service Factor	✓	✓

Comments and Observations:

TEC DESCRIPTION										PROGRAMMING														INSTALLATION VERIFICATION TEST					FUNCTIONAL VERIFICATION TEST									CUSTOMER ACCEPTANCE				
POINT NAME	AHU	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS	APPLICATION	INLET SIZE (DUCT DIAMETER OR DIMENSIONS if RECTANGULAR)	D or W	CALCULATED DUCT AREA	DAY CLG STPT	DAY HTG STPT	NGT CLG STPT	NGT HTG STPT	ROOM SETPOINT DIAL	CLG FLOW MIN	CLG FLOW MAX	HTG FLOW MIN	HTG FLOW MAX	FLOW COEFF	MTR2 TIMING	DMPR ROT ANG	MTR SETUP	LOCATION	CONFIRM INLET SIZE	VALVE ACTUATOR WIRING	DAMPER ACTUATOR WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ADDRESS	VERIFY ROOM TEMPERATURE	VERIFY FLN COMMUNICATION	VERIFY SHAFT MARKINGS AT 0%	VERIFY SHAFT MARKINGS AT 100%	VERIFY AIR FLOW AT 0%	VERIFY AIR FLOW AT 100%	VERIFY VALVE IS FULL CLOSED AT 0%	VERIFY VALVE IS FULL OPEN AT 100%	RELEASE VALVE AND DAMPER COMMANDS	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERIFY REHEAT VALVE OPERATION	VERIFY MAX CLG FLOW	VERIFY MIN CLG FLOW
								[02]			[97]	[96]	[97]	[08]	[09]	[14]	[31]	[32]	[33]	[34]	[36]	[55]	[56]	[56]																		
D3HQ.AC1.VAVRH1117	AC1	VAVRH1-1-17		MEC-01	1	1	4	2523			0.785	78	68	85	60		355	880	355	355	0.62	155	90	5																			
D3HQ.AC5.VAVRH1518	AC5	VAVRH1-5-18		MEC-01	1	1	5	2523			1.069	78	68	85	60		540	1800	540	540	0.62	155	90	5																			
D3HQ.AC5.VAVRH1519	AC5	VAVRH1-5-19		MEC-01	1	1	7	2523			1.069	78	68	85	60		540	1800	540	540	0.62	155	90	5																			
D3HQ.AC5.VAVRH1520	AC5	VAVRH1-5-20		MEC-01	1	1	8	2523			1.069	78	68	85	60		540	1800	540	540	0.62	155	90	5																			
D3HQ.AC5.VAVRH1521	AC5	VAVRH1-5-21		MEC-01	1	2	9	2523			0.785	78	68	85	60		325	1030	325	325	0.62	155	90	5																			
D3HQ.AC1.VAVRH1101	AC1	VAVRH1-1-01		MEC-01	1	2	10	2523			349	78	68	85	60		225	555	225	225	0.62	155	90	5																			
D3HQ.AC1.VAVRH1102	AC1	VAVRH1-1-02		MEC-01	1	2	12	2523			0.785	78	68	85	60		700	1200	700	700	0.62	155	90	5																			
D3HQ.AC2.VAVRH1203	AC2	VAVRH1-2-03		MEC-01	1	2	15	2523			545	78	68	85	60		300	810	300	300	0.62	155	90	5																			
D3HQ.AC2.VAVRH1204	AC2	VAVRH1-2-04		MEC-01	1	2	17	2523			349	78	68	85	60		145	800	145	145	0.62	155	90	5																			
D3HQ.AC2.VAVRH1205	AC2	VAVRH1-2-05		MEC-01	1	2	19	2523			1.069	78	68	85	60		455	1410	455	455	0.62	155	90	5																			
D3HQ.AC2.VAVRH1206	AC2	VAVRH1-2-06		MEC-01	1	2	20	2523			349	78	68	85	60		230	730	230	230	0.62	155	90	5																			
D3HQ.AC2.VAVRH1222	AC2	VAVRH1-2-22		MEC-01	1	1	22	2523			545	78	68	85	60		345	670	345	345	0.62	155	90	5																			
D3HQ.AC1.VAVRH2117	AC1	VAVRH2-1-17		MEC-01	1	2	4	2523			1.069	78	68	85	60		365	865	365	365	0.62	155	90	5																			
D3HQ.AC1.VAVRH2118	AC1	VAVRH2-1-18		MEC-01	1	2	5	2523			545	78	68	85	60		255	640	255	255	0.62	155	90	5																			
D3HQ.AC1.VAVRH2101	AC1	VAVRH2-1-01		MEC-01	1	1	6	2523			0.785	78	68	85	60		325	985	325	325	0.62	155	90	5																			
D3HQ.AC1.VAVRH2102	AC1	VAVRH2-1-02		MEC-01	1	1	9	2523			349	78	68	85	60		165	410	165	165	0.62	155	90	5																			
D3HQ.AC1.VAVRH2103	AC1	VAVRH2-1-03		MEC-01	1	1	11	2523			349	78	68	85	60		165	410	165	165	0.62	155	90	5																			
D3HQ.AC2.VAVRH2204	AC2	VAVRH2-2-04		MEC-01	1	2	14	2523			349	78	68	85	60		165	410	165	165	0.62	155	90	5																			
D3HQ.AC2.VAVRH2205	AC2	VAVRH2-2-05		MEC-01	1	2	16	2523			349	78	68	85	60		165	410	165	165	0.62	155	90	5																			
D3HQ.AC2.VAVRH2206	AC2	VAVRH2-2-06		MEC-01	1	2	18	2523			0.785	78	68	85	60		345	1410	345	345	0.62	155	90	5																			
D3HQ.AC2.VAVRH2207	AC2	VAVRH2-2-07		MEC-01	1	2	19	2523			545	78	68	85	60		345	865	345	345	0.62	155	90	5																			
D3HQ.AC1.VAVRH3116	AC1	VAVRH3-1-16		MEC-01	1	3	3	2523			1.069	78	68	85	60		485	1610	485	485	0.62	155	90	5																			
D3HQ.AC1.VAVRH3117	AC1	VAVRH3-1-17		MEC-01	1	3	4	2523			545	78	68	85	60		300	750	300	300	0.62	155	90	5																			
D3HQ.AC1.VAVRH3101	AC1	VAVRH3-1-01		MEC-01	1	3	5	2523			0.785	78	68	85	60		325	1035	325	325	0.62	155	90	5																			
D3HQ.AC1.VAVRH3102	AC1	VAVRH3-1-02		MEC-01	1	3	8	2523			189	78	68	85	60		85	205	85	85	0.62	155	90	5																			
D3HQ.AC1.VAVRH3103	AC1	VAVRH3-1-03		MEC-01	1	3	10	2523			349	78	68	95	60		165	410	165	165	0.62	155	90	5																			
D3HQ.AC2.VAVRH3204	AC2	VAVRH3-2-04		MEC-01	1	3	12	2523			349	78	68	85	60		165	410	165	165	0.62	155	90	5																			
D3HQ.AC2.VAVRH3205	AC2	VAVRH3-2-05		MEC-01	1	3	14	2523			349	78	68	85	60		165	410	165	165	0.62	155	90	5																			
D3HQ.AC2.VAVRH3206	AC2	VAVRH3-2-06		MEC-01	1	3	16	2523			0.785	78	68	85	60		380	1285	380	380	0.62	155	90	5																			
D3HQ.AC2.VAVRH3207	AC2	VAVRH3-2-07		MEC-01	1	3	17	2523			545	78	68	85	60		300	870	300	300	0.62	155	90	5																			
D3HQ.AC1.VAVRH4117	AC1	VAVRH4-1-17		MEC-02	1	1	1	2523			349	78	68	85	60		215	535	215	215	0.62	155	90	5																			
D3HQ.AC1.VAVRH4101	AC1	VAVRH4-1-01		MEC-02	1	1	2	2523			1.069	78	68	85	60		450	1415	450	450	0.62	155	90	5																			
D3HQ.AC1.VAVRH4102	AC1	VAVRH4-1-02		MEC-02	2	1	4	2523			545	78	68	85	60		265	660	265	265	0.62	155	90	5																			
D3HQ.AC2.VAVRH4203	AC2	VAVRH4-2-03		MEC-02	2	1	6	2523			349	78	68	85	60		195	490	195	195	0.62	155	90	5																			
D3HQ.AC2.VAVRH4204	AC2	VAVRH4-2-04		MEC-02	2	1	8	2523	B		349	78	67	85	60		155	390	155	155	0.62	155	90	5																			
D3HQ.AC2.VAVRH4205	AC2	VAVRH4-2-05		MEC-02	2	1	10	2523			0.785	78	68	85	60		340	1135	340	340	0.62	155	90	5																			
D3HQ.AC2.VAVRH4206	AC2	VAVRH4-2-06		MEC-02	2	1	11	2523			545	78	68	85	60		280	645	280	280	0.62	155	90	5																			

1) SHAFT MARKING AT 0% & 100% 10-12-08

12 NOV 2008

Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: Caltrans District 4 HQ Marysville, CA

POINT NAME	AHU	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS [01]	APPLICATION [02]	INLET SIZE (DUCT DIAMETER OR DIMENSIONS if RECTANGULAR) D or W	H	CALCULATED DUCT AREA [97]	DAY CLG STPT [06]	DAY HTG STPT [07]	NGT CLG STPT [08]	NGT HTG STPT [09]	ROOM SETPOINT DIAL [14]	CLG FLOW MIN [31]	CLG FLOW MAX [32]	HTG FLOW MIN [33]	HTG FLOW MAX [34]	FLOW COEFF [35]	MTR2 TIMING [55]	DMPR ROT ANG [56]	MTR SETUP [58]
TEC DESCRIPTION												PROGRAMMING												
D3HQ.AC3.VAVRH4307	AC3	VAVRH4-3-07		MEC-02	2	2	3	2523			1.389	78	68	85	60		635	2110	635	635	0.62	155	90	5
D3HQ.AC3.VAVRH4308	AHU-2E	VAVRH4-3-08		MEC-02	2	2	4	2523			1.069	78	68	85	60		450	1470	450	450	0.62	155	90	5
D3HQ.AC3.VAVRH4309	AC3	VAVRH4-3-09		MEC-02	2	2	6	2523			.545	78	68	85	60		300	800	300	300	0.62	155	90	5
D3HQ.AC4.VAVRH4410	AC4	VAVRH4-4-10		MEC-02	2	2	8	2523			.545	78	68	85	60		300	800	300	300	0.62	155	90	5
D3HQ.AC4.VAVRH4411	AC4	VAVRH4-4-11		MEC-02	2	2	10	2523	10		.545	78	68	85	60	NO	245	610	245	245	0.62	155	90	5
D3HQ.AC4.VAVRH4412	AC4	VAVRH4-4-12		MEC-02	2	2	11	2523			.545	78	68	85	60		300	910	300	300	0.62	155	90	5
D3HQ.AC4.VAVRH4413	AC4	VAVRH4-4-13		MEC-02	2	2	12	2523			0.785	78	68	85	60		341	1135	341	341	0.62	155	90	5
D3HQ.AC4.VAVRH4414	AC4	VAVRH4-4-14		MEC-02	2	2	13	2523			.545	78	68	85	60		300	820	300	300	0.62	155	90	5
D3HQ.AC4.VAVRH4415	AC4	VAVRH4-4-15		MEC-02	2	2	14	2523			.545	78	68	85	60		300	860	300	300	0.62	155	90	5
D3HQ.AC4.VAVRH4416	AC4	VAVRH4-4-16		MEC-02	2	2	15	2523			.545	78	68	85	60		340	845	340	340	0.62	155	90	5
D3HQ.AC1.VAVRH5101	AC1	VAVRH5-1-01		MEC-02	2	3	1	2523			.349	78	68	85	60		245	255	245	245	0.62	155	90	5
D3HQ.AC1.VAVRH5102	AC1	VAVRH5-1-02		MEC-02	2	3	2	2523			.545	78	68	85	60		310	755	310	310	0.62	155	90	5
D3HQ.AC1.VAVRH5103	AC1	VAVRH5-1-03		MEC-02	2	3	3	2523			0.785	78	68	85	60		375	1245	375	375	0.62	155	90	5
D3HQ.AC1.VAVRH5104	AC1	VAVRH5-1-04		MEC-02	2	3	5	2523			.545	78	68	85	60		260	650	260	260	0.62	155	90	5
D3HQ.AC1.VAVRH5105	AC1	VAVRH5-1-05		MEC-02	2	3	6	2523			.349	78	68	85	60		260	600	260	260	0.62	155	90	5
D3HQ.AC1 VAVRH5108	AC1	VAVRH5-1-08		MEC-02	2	3	8	2523			.545	78	68	85	60		300	800	300	300	0.62	155	90	5
D3HQ.AC2.VAVRH5209	AC2	VAVRH5-2-09		MEC-02	2	3	10	2523			.545	78	68	85	60		255	640	255	255	0.62	155	90	5
D3HQ.AC2.VAVRH5210	AC2	VAVRH5-2-10		MEC-02	2	3	12	2523			0.785	78	68	85	60		340	1240	340	340	0.62	155	90	5
D3HQ.AC2.VAVRH5201	AC2	VAVRH5-2-01		MEC-02	2	3	14	2523	12		0.785	78	68	85	60	NO	550	1050	550	550	0.62	155	90	5
D3HQ.AC1.VAVRH5107	AC1	VAVRH5-1-07		MEC-02	2	3	17	2523			1.069	78	68	85	60		492	1560	492	492	0.62	155	90	5
D3HQ.AC1.VAVRH5106	AC1	VAVRH5-1-06		MEC-02	2	3	18	2523			0.785	78	68	85	60		495	1285	495	495	0.62	155	90	5
D3HQ.AC3.VAVRH3308	AC3	VAVRH3-3-08		MEC-03	3	3	3	2523			1.396	78	68	85	60		615	2050	615	615	0.62	155	90	5
D3HQ.AC3.VAVRH3309	AC3	VAVRH3-3-09		MEC-03	3	3	4	2523			1.069	78	68	85	60		475	1585	475	475	0.62	155	90	5
D3HQ.AC3.VAVRH3310	AC3	VAVRH3-3-10		MEC-03	3	3	6	2523			0.785	78	68	85	60		325	965	325	325	0.62	155	90	5
D3HQ.AC3.VAVRH3311	AC3	VAVRH3-3-11		MEC-03	3	3	8	2523			.349	78	68	85	60		145	360	145	145	0.62	155	90	5
D3HQ.AC4.VAVRH3412	AC4	VAVRH3-4-12		MEC-03	3	3	9	2523			.349	78	68	85	60		215	540	215	215	0.62	155	90	5
D3HQ.AC4.VAVRH3413	AC4	VAVRH3-4-13		MEC-03	3	3	11	2523			0.785	78	68	85	60		345	1150	345	345	0.62	155	90	5
D3HQ.AC4.VAVRH3415	AC4	VAVRH3-4-15		MEC-03	3	3	14	2523			.545	78	68	85	60		300	900	300	300	0.62	155	90	5
D3HQ.AC3.VAVRH2308	AC3	VAVRH2-3-08		MEC-03	3	2	3	2523			.545	78	68	85	60		345	745	345	345	0.62	155	90	5
D3HQ.AC3.VAVRH2309	AC3	VAVRH2-3-09		MEC-03	3	2	6	2523			.545	78	68	85	60		300	900	300	300	0.62	155	90	5
D3HQ.AC3.VAVRH2310	AC3	VAVRH2-3-10		MEC-03	3	2	7	2523			1.069	78	68	85	60		475	1590	475	475	0.62	155	90	5
D3HQ.AC3.VAVRH2311	AC3	VAVRH2-3-11		MEC-03	3	2	9	2523			.545	78	68	85	60		300	800	300	300	0.62	155	90	5
D3HQ.AC4.VAVRH2412	AC4	VAVRH2-4-12		MEC-03	3	2	11	2523			.349	78	68	85	60		225	580	225	225	0.62	155	90	5
D3HQ.AC4.VAVRH2414	AC4	VAVRH2-4-14		MEC-03	3	2	15	2523	10		~~.349~~ .545	78	68	85	60	NO	300	800	300	300	0.62	155	90	5
D3HQ.AC4.VAVRH2415	AC4	VAVRH2-4-15		MEC-03	3	2	17	2523	14		1.069	78	68	85	60	NO	455	1520	455	455	0.62	155	90	5
D3HQ.AC4.VAVRH2416	AC4	VAVRH2-4-16		MEC-03	3	2	18	2523			1.069	78	68	85	60		585	1460	585	585	0.62	155	90	5
D3HQ.AC3.VAVRH1307	AC3	VAVRH1-3-07		MEC-03	3	1	2	2523			0.785	78	68	85	60		300	1070	300	300	0.52	155	90	5

POINT NAME	LOCATION	CONFIRM INLET SIZE	VALVE ACTUATOR WIRING	DAMPER ACTUATOR WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ADDRESS	VERIFY ROOM TEMPERATURE	VERIFY FLN COMMUNICATION	VERIFY SHAFT MARKINGS AT 0%	VERIFY AIR FLOW AT 0%	VERIFY SHAFT MARKINGS AT 100%	VERIFY AIR FLOW AT 100%	VERIFY VALVE IS FULL CLOSED AT 0%	VERIFY VALVE IS FULL OPEN AT 100%	RELEASE VALVE AND DAMPER COMMANDS	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERIFY REHEAT VALVE OPERATION	VERIFY MAX CLG FLOW	VERIFY MIN CLG FLOW
	INSTALLATION VERIFICATION TEST						FUNCTIONAL VERIFICATION TEST										CUSTOMER ACCEPTANCE				
D3HQ.AC3.VAVRH4307	[initials]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	[initials]					
D3HQ.AC3.VAVRH4308																					
D3HQ.AC3.VAVRH4309																					
D3HQ.AC4.VAVRH4410	[initials]					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
D3HQ.AC4.VAVRH4411	Y	Y	Y	Y	Y	Y	10	72.75	✓	0	0	100	1772	0	100	CSF					
D3HQ.AC4.VAVRH4412	[initials]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	[initials]					
D3HQ.AC4.VAVRH4413																					
D3HQ.AC4.VAVRH4414																					
D3HQ.AC4.VAVRH4415																					
D3HQ.AC4.VAVRH4416																					
D3HQ.AC1.VAVRH5101																					
D3HQ.AC1.VAVRH5102																					
D3HQ.AC1.VAVRH5103																					
D3HQ.AC1.VAVRH5104																					
D3HQ.AC1.VAVRH5105																					
D3HQ.AC1 VAVRH5108																					
D3HQ.AC2.VAVRH5209																					
D3HQ.AC2.VAVRH5210	[initials]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	[initials]					
D3HQ.AC2.VAVRH5201	Y	Y	Y	Y	Y	Y	14	✓	✓	0	0	100	794	0	100	CSF					
D3HQ.AC1.VAVRH5107	[initials]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	[initials]					
D3HQ.AC1.VAVRH5106																					
D3HQ.AC3.VAVRH3308																					
D3HQ.AC3.VAVRH3309																					
D3HQ.AC3.VAVRH3310																					
D3HQ.AC3.VAVRH3311																					
D3HQ.AC4.VAVRH3412																					
D3HQ.AC4.VAVRH3413																					
D3HQ.AC4.VAVRH3415																					
D3HQ.AC3.VAVRH2308																					
D3HQ.AC3.VAVRH2309																					
D3HQ.AC3.VAVRH2310																					
D3HQ.AC3.VAVRH2311																					
D3HQ.AC4.VAVRH2412	[initials]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	[initials]					
D3HQ.AC4.VAVRH2414	Y	Y	Y	Y	Y	Y	15	✓	✓	0	36	100	1552	0	100	CSF					
D3HQ.AC4.VAVRH2415	Y	Y	Y	Y	Y	Y	17	✓	✓	0	0	100	2916	0	100	CSF					
D3HQ.AC4.VAVRH2416	[initials]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	[initials]					
D3HQ.AC3.VAVRH1307	[initials]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	[initials]					

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[signature]

Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: Caltrans District 4 HQ Marysville, CA

TEC DESCRIPTION												PROGRAMMING													INSTALLATION VERIFICATION TEST						FUNCTIONAL VERIFICATION TEST										CUSTOMER ACCEPTANCE				
POINT NAME	AHU	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	[01] TEC ADDRESS	[02] APPLICATION	INLET SIZE (DUCT DIAMETER OR DIMENSIONS if RECTANGULAR) D or W	H	[97] CALCULATED DUCT AREA	[06] DAY CLG STPT	[07] DAY HTG STPT	[08] NGT CLG STPT	[09] NGT HTG STPT	[14] ROOM SETPOINT DIAL	[31] CLG FLOW MIN	[32] CLG FLOW MAX	[33] HTG FLOW MIN	[34] HTG FLOW MAX	[36] FLOW COEFF	[56] MTR2 TIMING	[54] DMPR ROT ANG	[58] MTR SETUP	LOCATION	CONFIRM INLET SIZE	VALVE ACTUATOR WIRING	DAMPER ACTUATOR WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ADDRESS	VERIFY ROOM TEMPERATURE	VERIFY FLN COMMUNICATION	VERIFY SHAFT MARKINGS AT 0%	VERIFY AIR FLOW AT 0%	VERIFY SHAFT MARKINGS AT 100%	VERIFY AIR FLOW AT 100%	VERIFY VALVE IS FULL CLOSED AT 0%	VERIFY VALVE IS FULL OPEN AT 100%	RELEASE VALVE AND DAMPER COMMANDS	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERIFY REHEAT VALVE OPERATION	VERIFY MAX CLG FLOW	VERIFY MIN CLG FLOW
D3HQ.AC3.VAVRH1308	AC3	VAVRH1-3-08		MEC-03	3	1	4	2523			1.069	78	68	85	60	ND	450	1455	450	450	0.62	155	90	5	TL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
D3HQ.AC3.VAVRH1309	AC3	VAVRH1-3-09		MEC-03	3	1	6	2523			.545	78	68	85	60		300	800	300	300	0.62	155	90	5																					
D3HQ.AC4.VAVRH1410	AC4	VAVRH1-4-10		MEC-03	3	1	10	2523			.545	78	68	85	60		300	780	300	300	0.62	155	90	5																					
D3HQ.AC4.VAVRH1411	AC4	VAVRH1-4-11		MEC-03	3	1	11	2523			.545	78	68	85	60		295	790	295	295	0.62	155	90	5																					
D3HQ.AC4.VAVRH1412	AC4	VAVRH1-4-12		MEC-03	3	1	12	2523			.545	78	68	85	60		315	780	315	315	0.62	155	90	5																					
D3HQ.AC4.VAVRH1413	AC4	VAVRH1-4-13		MEC-03	3	1	13	2523			.349	78	68	85	60		100	210	100	100	0.62	155	90	5																					
D3HQ.AC4.VAVRH1414	AC4	VAVRH1-4-14		MEC-03	3	1	14	2523			0.785	78	68	85	60		900	1020	900	900	0.62	155	90	5																					
D3HQ.AC4.VAVRH1415	AC4	VAVRH1-4-15		MEC-03	3	1	15	2523			0.785	78	68	85	60		1100	1250	1100	1100	0.62	155	90	5																					
D3HQ.AC4.VAVRH1416	AC4	VAVRH1-4-16		MEC-03	3	1	16	2523			1.069	78	68	85	60	ND	1500	1650	1500	1500	0.62	155	90	5	TL	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					

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Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: CalTtrans Division 3 HQ. Marysville,California

TEC DESCRIPTION													PROGRAMMING													INSTALLATION VERIFICATION TEST					FUNCTIONAL VERIFICATION TEST								CUSTOMER ACCEPTANCE			
POINT NAME	AHU	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS [01]	APPLICATION [02]	INLET SIZE (DUCT DIAMETER OR DIMENSIONS if RECTANGULAR) D or W	H	CALCULATED DUCT AREA [97]	DAY CLG STPT [06]	DAY HTG STPT [07]	NGT CLG STPT [08]	NGT HTG STPT [09]	ROOM SETPOINT DIAL [14]	CLG FLOW MIN [31]	CLG FLOW MAX [32]	HTG FLOW MIN [33]	HTG FLOW MAX [34]	FLOW COEFF [36]	MTR2 TIMING [55]	DMPR ROT ANG [56]	MTR SETUP [58]	LOCATION	CONFIRM INLET SIZE	DAMPER ACTUATOR WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ADDRESS	VERIFY ROOM TEMPERATURE	VERIFY FLN COMMUNICATION	VERIFY SHAFT MARKINGS AT 0%	VERIFY AIR FLOW AT 0%	VERIFY SHAFT MARKINGS AT 100%	VERIFY AIR FLOW AT 100%	RELEASE DAMPER COMMANDS	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERIFY MAX CLG FLOW	VERIFY MIN CLG FLOW
D3HQ.AC3.VAVCO4314	AC3	VAVC04-3-14		MEC-02	2	2	7	2521	11		1.069	78	68	85	60	20	450	1545	0	450	0.62	N/A	95	1	Y	Y	Y	Y	Y	7	72	✓	0	0	100	2320	65				
D3HQ.AC4.VAVCO4420	AC4	VAVC04-4-20		MEC-02	2	2	16	2521			0.785	78	68	85	60		325	1000	0	325	0.62	N/A	95	1	OK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OK				
D3HQ.AC4.VAVCO4419	AC4	VAVC04-4-19		MEC-02	2	2	17	2521			0.349	78	68	85	60		300	420	0	300	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO4418	AC4	VAVC04-4-18		MEC-02	2	2	18	2521			0.785	78	68	85	60		500	1185	0	500	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO4417	AC4	VAVC04-4-17		MEC-02	2	2	19	2521			1.069	78	68	85	60		500	1160	0	500	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO4416	AC4	VAVC04-4-16		MEC-02	2	2	20	2521			1.069	78	68	85	60		450	1740	0	450	0.62	N/A	95	1	OK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OK				
D3HQ.AC1.VAVCO5101	AC1	VAVC05-1-01		MEC-02	2	3	4	2521	8		0.349	78	68	85	60	20	250	460	0	250	0.62	N/A	95	1	Y	Y	Y	Y	Y	4	67	✓	0	0	100	964	65				
D3HQ.AC1.VAVCO5102	AC1	VAVC05-1-02		MEC-02	2	3	7	2521			0.785	78	68	85	60		325	1110	0	325	0.62	N/A	95	1	OK	OK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OK				
D3HQ.AC2.VAVCO5203	AC2	VAVC05-2-03		MEC-02	2	3	9	2521			0.785	78	68	85	60		325	1480	0	325	0.62	N/A	95	1																	
D3HQ.AC2.VAVCO5205	AC2	VAVC05-2-05		MEC-02	2	3	11	2521			1.069	78	68	85	60		450	1480	0	450	0.62	N/A	95	1																	
D3HQ.AC2.VAVCO5207	AC2	VAVC05-2-07		MEC-02	2	3	13	2521			2.667	78	68	85	60		1400	3200	0	1400	0.62	N/A	95	1																	
D3HQ.AC2.VAVCO5206	AC2	VAVC05-2-06		MEC-02	2	3	15	2521			0.349	78	68	85	60		165	350	0	165	0.62	N/A	95	1																	
D3HQ.AC2.VAVCO5204	AC2	VAVC05-2-04		MEC-02	2	3	16	2521			0.349	78	68	85	60		240	595	0	240	0.62	N/A	95	1																	
D3HQ.AC1.VAVCO4415	AC1	VAVC04-4-15		MEC-02	2	2	9	2521			0.349	78	68	85	60		165	610	0	165	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO1311	AC3	VAVC01-3-11		MEC-03	3	1	1	2521			0.785	78	68	85	60		325	1215	0	325	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO1322	AC3	VAVC01-3-22		MEC-03	3	1	3	2521			1.396	78	68	85	60		580	2900	0	580	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO1310	AC3	VAVC01-3-10		MEC-03	3	1	5	2521			0.785	78	68	85	60		325	1400	0	325	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO1312	AC3	VAVC01-3-12		MEC-03	3	1	7	2521			0.349	78	68	85	60		255	645	0	255	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO1313	AC3	VAVC01-3-13		MEC-03	3	1	8	2521			0.785	78	68	85	60		325	1100	0	325	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO1314	AC3	VAVC01-3-14		MEC-03	3	1	9	2521			0.349	78	68	85	60		240	625	0	240	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO1418	AC4	VAVC01-4-18		MEC-03	3	1	17	2521			0.545	78	68	85	60		240	915	0	240	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO1417	AC4	VAVC01-4-17		MEC-03	3	1	18	2521			0.196	78	68	85	60		200	340	0	200	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO1416	AC4	VAVC01-4-16		MEC-03	3	1	19	2521			0.196	78	68	85	60		200	340	0	200	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO1415	AC4	VAVC01-4-15		MEC-03	3	1	20	2521			0.196	78	68	85	60		200	340	0	200	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO2314	AC3	VAVC02-3-14		MEC-03	3	2	1	2521			0.349	78	68	85	60	NO	210	360	0	210	0.62	N/A	95	1	OK	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OK				

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Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: CalTtrans Division 3 HQ. Marysville,California

TEC DESCRIPTION													PROGRAMMING													INSTALLATION VERIFICATION TEST					FUNCTIONAL VERIFICATION TEST								CUSTOMER ACCEPTANCE			
POINT NAME	AHU	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS [01]	APPLICATION [02]	INLET SIZE (DUCT DIAMETER OR DIMENSIONS if RECTANGULAR) D or W	H	CALCULATED DUCT AREA [97]	DAY CLG STPT [06]	DAY HTG STPT [07]	NGT CLG STPT [08]	NGT HTG STPT [09]	ROOM SETPOINT DIAL [14]	CLG FLOW MIN [31]	CLG FLOW MAX [32]	HTG FLOW MIN [33]	HTG FLOW MAX [34]	FLOW COEFF [36]	MTR2 TIMING [55]	DMPR ROT ANG [56]	MTR SETUP [58]	LOCATION	CONFIRM INLET SIZE	DAMPER ACTUATOR WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ADDRESS	VERIFY ROOM TEMPERATURE	VERIFY FLN COMMUNICATION	VERIFY SHAFT MARKINGS AT 0%	VERIFY AIR FLOW AT 0%	VERIFY SHAFT MARKINGS AT 100%	VERIFY AIR FLOW AT 100%	RELEASE DAMPER COMMANDS	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERIFY MAX CLG FLOW	VERIFY MIN CLG FLOW
D3HQ.AC3.VAVCO2313	AC3	VAVC02-3-13		MEC-03	3	2	2	2521			0.785	78	68	85	60	NO	600	1045	0	600	0.62	N/A	95	1	Tw	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Tw				
D3HQ.AC3.VAVCO2315	AC3	VAVC02-3-15		MEC-03	3	2	4	2521			0.545	78	68	85	60		655	655	0	655	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO2316	AC3	VAVC02-3-16		MEC-03	3	2	5	2521			0.785	78	68	85	60		325	1200	0	325	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO2317	AC3	VAVC02-3-17		MEC-03	3	2	8	2521			0.785	78	68	85	60		325	1300	0	325	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO2318	AC3	VAVC02-3-18		MEC-03	3	2	10	2521			0.785	78	68	85	60		325	1110	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO2419	AC4	VAVC02-4-19		MEC-03	3	2	12	2521			0.785	78	68	85	60		325	1110	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO2420	AC4	VAVC02-4-20		MEC-03	3	2	13	2521			1.069	78	68	85	60		450	1600	0	450	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO2421	AC4	VAVC02-4-21		MEC-03	3	2	14	2521			1.069	78	68	85	60		450	1480	0	450	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO2423	AC4	VAVC02-4-23		MEC-03	3	2	16	2521			0.785	78	68	85	60		325	1280	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO2422	AC4	VAVC02-4-22		MEC-03	3	2	19	2521			0.545	78	68	85	60		285	800	0	285	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO3317	AC3	VAVC03-3-17		MEC-03	3	3	1	2521			0.545	78	68	85	60		230	780	0	230	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO3315	AC3	VAVC03-3-15		MEC-03	3	3	2	2521			0.785	78	68	85	60		325	1040	0	325	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO3316	AC3	VAVC03-3-16		MEC-03	3	3	5	2521			0.785	78	68	85	60		450	1430	0	450	0.62	N/A	95	1																	
D3HQ.AC3.VAVCO3318	AC3	VAVC03-3-18		MEC-03	3	3	7	2521			0.785	78	68	85	60		325	1080	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO3420	AC4	VAVC03-4-20		MEC-03	3	3	10	2521			0.785	78	68	85	60		325	1080	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO3422	AC4	VAVC03-4-22		MEC-03	3	3	12	2521			0.785	78	68	85	60		325	1080	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO3423	AC4	VAVC03-4-23		MEC-03	3	3	13	2521			0.785	78	68	85	60		325	1070	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO3424	AC4	VAVC03-4-24		MEC-03	3	3	15	2521			0.545	78	68	85	60		230	975	0	230	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO3421	AC4	VAVC03-4-21		MEC-03	3	3	16	2521			0.785	78	68	85	60		325	1150	0	325	0.62	N/A	95	1																	
D3HQ.AC4.VAVCO3419	AC4	VAVC03-4-19		MEC-03	3	3	17	2521			1.069	78	68	85	60	NO	450	1600	0	450	0.62	N/A	95	1	Tw	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Tw				

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Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: CalTtrans Division 3 HQ. Marysville,California

TEC DESCRIPTION													PROGRAMMING													INSTALLATION VERIFICATION TEST					FUNCTIONAL VERIFICATION TEST								CUSTOMER ACCEPTANCE			
POINT NAME	AHU	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS [01]	APPLICATION [02]	INLET SIZE (DUCT DIAMETER OR DIMENSIONS if RECTANGULAR) D or W	H	CALCULATED DUCT AREA [97]	DAY CLG STPT [06]	DAY HTG STPT [07]	NGT CLG STPT [08]	NGT HTG STPT [09]	ROOM SETPOINT DIAL [14]	CLG FLOW MIN [31]	CLG FLOW MAX [32]	HTG FLOW MIN [33]	HTG FLOW MAX [34]	FLOW COEFF [36]	MTR2 TIMING [55]	DMPR ROT ANG [56]	MTR SETUP [58]	LOCATION	CONFIRM INLET SIZE	DAMPER ACTUATOR WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ADDRESS	VERIFY ROOM TEMPERATURE	VERIFY FLN COMMUNICATION	VERIFY SHAFT MARKINGS AT 0%	VERIFY AIR FLOW AT 0%	VERIFY SHAFT MARKINGS AT 100%	VERIFY AIR FLOW AT 100%	RELEASE DAMPER COMMANDS	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERIFY MAX CLG FLOW	VERIFY MIN CLG FLOW
D3HQ.AC1.VAVCO1101	AC1	VAVC01-1-01		MEC-01	1	1	1	2521	5		0.4	78	68	85	60	NO	285	844	0	285	0.62	N/A	95	1	OTW	OTW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OTW				
D3HQ.AC1.VAVCO1119	AC1	VAVC01-1-19		MEC-01	1	1	2	2521			0.545	78	68	85	60		530	775	0	530	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO1520	AC1	VAVC01-5-20		MEC-01	1	1	3	2521			1.069	78	68	85	60		450	1935	0	450	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO1521	AC1	VAVC01-5-21		MEC-01	1	1	6	2521			1.069	78	68	85	60		450	1935	0	450	0.62	N/A	95	1	OTW	OTW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OTW				
D3HQ.AC2.VAVCO1102	AC2	VAVC01-1-11		MEC-01	1	1	11	2521	14		1.069 ~~0.785~~	78	68	85	60	NO	325	1300	0	325	0.62	N/A	95	1	Y	Y	Y	Y	Y	11	65.5	✓	0	0	100	2264	OTW				
D3HQ.AC2.VAVCO1206	AC2	VAVC01-2-06		MEC-01	1	1	24	2521			0.349	78	68	85	60		105	260	0	105	0.62	N/A	95	1	OTW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
D3HQ.AC2.VAVCO1207	AC2	VAVC01-2-07		MEC-01	1	1	23	2521			0.545	78	68	85	60		450	800	0	450	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO1208	AC2	VAVC01-2-08		MEC-01	1	1	21	2521			0.349	78	68	85	60		220	570	0	220	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO1209	AC2	VAVC01-2-09		MEC-01	1	1	18	2521			0.545	78	68	85	60		230	830	0	230	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO1205	AC2	VAVC01-2-05		MEC-01	1	1	16	2521			0.349	78	68	85	60		255	385	0	255	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO1104	AC1	VAVC01-1-04		MEC-01	1	1	14	2521			0.545	78	68	85	60		230	995	0	230	0.62	N/A	95	1	OTW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
D3HQ.AC1.VAVCO1103	AC1	VAVC01-1-03		MEC-01	1	1	13	2521	10		0.545 ~~0.349~~	78	68	85	60	NO	270	520	0	270	0.62	N/A	95	1	Y	Y	Y	Y	Y	13	✓	✓	0	0	100	156	OTW				
D3HQ.AC1.VAVCO2104	AC1	VAVC02-1-04		MEC-01	1	2	1	2521			0.349	78	68	85	60		225	500	0	225	0.62	N/A	95	1	OTW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
D3HQ.AC1.VAVCO2124	AC1	VAVC02-1-24		MEC-01	1	2	2	2521			1.069	78	68	85	60		450	1120	0	450	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO2101	AC1	VAVC02-1-01		MEC-01	1	2	3	2521			0.545	78	68	85	60		230	740	0	230	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO2103	AC1	VAVC02-1-03		MEC-01	1	2	7	2521			1.069	78	68	85	60		450	1440	0	450	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO2102	AC1	VAVC02-1-02		MEC-01	1	2	8	2521			0.545	78	68	85	60		230	685	0	230	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO2105	AC1	VAVC02-1-05		MEC-01	1	2	10	2521			1.069	78	68	85	60		450	1420	0	450	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO2106	AC1	VAVC02-1-06		MEC-01	1	2	12	2521			1.396	78	68	85	60		580	1470	0	580	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO2207	AC2	VAVC02-2-07		MEC-01	1	2	13	2521			0.785	78	68	85	60		325	1440	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO2208	AC2	VAVC02-2-08		MEC-01	1	2	15	2521			0.785	78	68	85	60		325	1440	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO2212	AC2	VAVC02-2-12		MEC-01	1	2	17	2521			0.785	78	68	85	60		325	1410	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO2211	AC2	VAVC02-2-11		MEC-01	1	2	20	2521			0.545	78	68	85	60		280	770	0	280	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO2210	AC2	VAVC02-2-10		MEC-01	1	2	21	2521			0.785	78	68	85	60		325	1120	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO2209	AC2	VAVC02-2-09		MEC-01	1	2	22	2521			0.785	78	68	85	60		325	1200	0	325	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO3101	AC1	VAVC03-1-01		MEC-01	1	3	1	2521			0.545	78	68	85	60	NO	230	760	0	230	0.62	N/A	95	1	OTW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OTW				

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Commissioning Summary Sheets
Project: CalTtrans Division 3 HQ. Marysville,California

TEC DESCRIPTION													PROGRAMMING													INSTALLATION VERIFICATION TEST					FUNCTIONAL VERIFICATION TEST								CUSTOMER ACCEPTANCE			
POINT NAME	AHU	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS [01]	APPLICATION [02]	INLET SIZE (DUCT DIAMETER OR DIMENSIONS if RECTANGULAR) D or W	H	CALCULATED DUCT AREA [97]	DAY CLG STPT [06]	DAY HTG STPT [07]	NGT CLG STPT [08]	NGT HTG STPT [09]	ROOM SETPOINT DIAL [14]	CLG FLOW MIN [31]	CLG FLOW MAX [32]	HTG FLOW MIN [33]	HTG FLOW MAX [34]	FLOW COEFF [36]	MTR2 TIMING [55]	DMPR ROT ANG [56]	MTR SETUP [58]	LOCATION	CONFIRM INLET SIZE	DAMPER ACTUATOR WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ADDRESS	VERIFY ROOM TEMPERATURE	VERIFY FLN COMMUNICATION	VERIFY SHAFT MARKINGS AT 0%	VERIFY AIR FLOW AT 0%	VERIFY SHAFT MARKINGS AT 100%	VERIFY AIR FLOW AT 100%	RELEASE DAMPER COMMANDS	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERIFY MAX CLG FLOW	VERIFY MIN CLG FLOW
D3HQ.AC1.VAVCO3102	AC1	VAVC03-1-02		MEC-01	1	3	2	2521			0.545	78	68	85	60	no	240	630	0	240	0.62	N/A	95	1	OTM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OTM				
D3HQ.AC1.VAVCO3103	AC1	VAVC03-1-03		MEC-01	1	3	6	2521			0.785	78	68	85	60		325	1100	0	325	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO3104	AC1	VAVC03-1-04		MEC-01	1	3	7	2521			0.349	78	68	85	60		145	360	0	145	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO3105	AC1	VAVC03-1-05		MEC-01	1	3	9	2521			0.545	78	68	85	60		250	690	0	250	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO3107	AC1	VAVC03-1-07		MEC-01	1	3	11	2521			1.069	78	68	85	60		450	1440	0	450	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO3209	AC2	VAVC03-2-09		MEC-01	1	3	13	2521			1.069	78	68	85	60		450	1440	0	450	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO3213	AC2	VAVC03-2-13		MEC-01	1	3	15	2521			0.785	78	68	85	60		240	1410	0	240	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO3214	AC2	VAVC03-2-14		MEC-01	1	3	18	2521			0.785	78	68	85	60		325	1175	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO3212	AC2	VAVC03-2-12		MEC-01	1	3	19	2521			0.545	78	68	85	60		240	875	0	240	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO3211	AC2	VAVC03-2-11		MEC-01	1	3	20	2521			0.785	78	68	85	60		325	1130	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO3210	AC2	VAVC03-2-10		MEC-01	1	3	21	2521			1.069	78	68	85	60		450	1500	0	450	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO3208	AC2	VAVC03-2-08		MEC-01	1	3	22	2521			0.785	78	68	85	60		325	1120	0	325	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO3106	AC1	VAVC03-1-06		MEC-01	1	3	23	2521			0.545	78	68	85	60		315	600	0	315	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO4102	AC1	VAVC04-1-02		MEC-02	2	1	3	2521			0.545	78	68	85	60		230	750	0	230	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO4104	AC1	VAVC04-1-04		MEC-02	2	1	5	2521			0.785	78	68	85	60		325	1380	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO4205	AC2	VAVC04-2-05		MEC-02	2	1	7	2521			0.785	78	68	85	60		325	1380	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO4209	AC2	VAVC04-2-09		MEC-02	2	1	9	2521			0.785	78	68	85	60		325	1380	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO4210	AC2	VAVC04-2-10		MEC-02	2	1	12	2521			0.785	78	68	85	60		325	1320	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO4208	AC2	VAVC04-2-08		MEC-02	2	1	13	2521			0.785	78	68	85	60		325	1080	0	325	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO4207	AC2	VAVC04-2-07		MEC-02	2	1	14	2521			0.545	78	68	85	60		250	950	0	250	0.62	N/A	95	1																		
D3HQ.AC2.VAVCO4206	AC2	VAVC04-2-06		MEC-02	2	1	15	2521			1.069	78	68	85	60		450	1560	0	450	0.62	N/A	95	1																		
D3HQ.AC1.VAVCO4103	AC1	VAVC04-1-03		MEC-02	2	1	16	2521			1.069	78	68	85	60		450	1560	0	450	0.62	N/A	95	1																		
D3HQ.AC3.VAVCO4313	AC3	VAVC04-3-13		MEC-02	2	2	1	2521			0.545	78	68	85	60		400	930	0	400	0.62	N/A	95	1																		
D3HQ.AC3.VAVCO4311	AC3	VAVC04-3-11		MEC-02	2	2	2	2521			0.785	78	68	85	60		325	1240	0	325	0.62	N/A	95	1																		
D3HQ.AC3.VAVCO4312	AC3	VAVC04-3-12		MEC-02	2	2	5	2521			0.785	78	68	85	60	no	325	1280	0	325	0.62	N/A	95	1	OTM	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	OTM	OTM				

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Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: Caltrans District 3 HQ Marysville, CA

TEC DESCRIPTION														INSTALLATION VERIFICATION TEST				SIEMENS ~~CUSTOMER~~ ACCEPTANCE			
POINT NAME	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS [01]	APPLICATION [02]	DAY CLG STPT [06]	DAY HTG STPT [07]	NGT CLG STPT [08]	NGT HTG STPT [09]	ROOM SETPOINT DIAL [14]	MTR SETUP [58]	LOCATION	VERIFY WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERFIY COMPRESSOR	VERIFY FAN STATUS
D3HQ.PCU1	PCU1		MEC 01	1	1	27	2070	74	70	74	65	NO	0	✓	✓	✓	✓	✓	N/A	✓	✓
D3HQ.PCU10	PCU10		MEC 01	1	3	26	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU11	PCU11		MEC 03	3	3	21	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU12	PCU8		MEC O3	3	3	20	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU13	PCU 13		MEC 02	2	3	19	2273	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU14	PCU14		MEC 02	2	1	17	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU15	PCU15		MEC 02	2	1	18	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU16	PCU16		MEC 02	2	2	21	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU17	PCU17		MEC 02	2	2	22	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU18	PCU18		MEC 02	2	3	22	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU2	PCU2		MEC 03	3	1	23	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU20	PCU20		MEC 02	2	3	21	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU22	PCU22		MEC 03	3	1	24	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU24	PCU24		MEC 01	1	1	26	2070	74	70	74	65	NO	0	✓					N/A		
D3HQ.PCU25	PCU25		MEC 01	1	1	25	2070	74	70	74	65	NO	0	✓	✓	✓	✓	✓	N/A	✓	✓

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Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: Caltrans District 3 HQ Marysville, CA

TEC DESCRIPTION														INSTALLATION VERIFICATION TEST				SIEMENS ~~CUSTOMER~~ ACCEPTANCE			
POINT NAME	BOX TAG (FROM MECH DWGS)	XFMR PANEL/CIRCUIT	FIELD PANEL TAG	FIELD PANEL ADDRESS	FLN	TEC ADDRESS [01]	APPLICATION [02]	DAY CLG STPT [06]	DAY HTG STPT [07]	NGT CLG STPT [08]	NGT HTG STPT [09]	ROOM SETPOINT DIAL [14]	MTR SETUP [58]	LOCATION	VERIFY WIRING	24VAC POWER	ESTABLISH COMMUNICATION	VERIFY ROOM TEMPERATURE	VERIFY ROOM TEMPERATURE SETPOINT	VERFIY COMPRESSOR	VERIFY FAN STATUS
D3HQ.PCU26	PCU26		MEC 03	3	1	25	2070	74	70	74	65	NO	0	✓	✓	✓	✓	✓	N/A	✓	✓
D3HQ.PCU3	PCU3		MEC 03	3	1	22	2070	74	70	74	65	NO	0						N/A		
D3HQ.PCU4	PCU4		MEC 03	3	1	21	2070	74	70	74	65	NO	0						N/A		
D3HQ.PCU5	PCU5		MEC 01	1	2	25	2070	74	70	74	65	NO	0						N/A		
D3HQ.PCU6	PCU6		MEC 01	1	2	24	2070	74	70	74	65	NO	0						N/A		
D3HQ.PCU7	PCU7		MEC 03	3	2	20	2070	74	70	74	65	NO	0						N/A		
D3HQ.PCU8	PCU8		MEC 03	3	2	21	2070	74	70	74	65	NO	0						N/A		
D3HQ.PCU9	PCU9		MEC 01	1	3	25	2070	74	70	74	65	NO	0	✓	✓	✓	✓	✓	N/A	✓	✓

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MEC -01					Siemens Acceptance								
Point Name	Point Description	Point Type	Point Function	Address	Proper Installation	Point To Point	Procedure Number	Alarm Status	Displayed Value	Actual Value	Accepted	Date	Accepted By
D3HQ.BLR1.SS	BOILER 1 ENABLE	LDO	On/Off	0.0.25	OK	OK	N/A	NO	ON/OFF	ON/OFF	OK	12/5/08	OK
D3HQ.BLR2.SS	BOILER 2 ENABLE	LDO	On/Off	0.0.26				NO	ON/OFF	ON/OFF			
D3HQ.BLR3.SS	BOILER 3 ENABLE	LDO	On/Off	0.0.27				NO	ON/OFF	ON/OFF			
D3HQ.HWP1.Fault	HWP1 FAULT	LDI	Status	0.0.6				YES	OFF	OFF			
D3HQ.HWP2.Fault	HWP2 FAULT	LDI	Status	0.0.7				YES	OFF	OFF			
D3HQ.BLR1.Alarm	BOILER 1 ALARM	LDI	Status	0.0.1				YES	OFF	OFF			
D3HQ.BLR2.Alarm	BOILER 2 ALARM	LDI	Status	0.0.2				YES	OFF	OFF			
D3HQ.BLR3.Alarm	BOILER 3 ALARM	LDI	Status	0.0.3				YES	OFF	OFF			
D3HQ.HWP1.Speed	HWP 1 SPEED	LAO	Value	0.0.9				NO	32 %	32.6 %			
D3HQ.HWP2.Speed	HWP 2 SPEED	LAO	Value	0.0.10				NO	0 %	0 %			
D3HQ.HW.EOLDP	END OF LINE DP	LAI	Value	0.0.19				NO	1.02	1.03			
D3HQ.PrimHW.Sup.Temp	BLR1_2 SUP TEMP	LAI	Value	0.0.21				YES	78	78.6			
D3HQ.PrimHW.RetTemp	HW RET TEMP	LAI	Value	0.0.22				YES	78	78.3			
D3HQ.SecHW.Flow	HW FLOW METER	LAI	Value	0.0.20				NO	136	136.3			
D3HQ.SecHW.RetTemp	HW RETURN TEMP	LAI	Value	0.0.18				YES	78.3	78.7			
D3HQ.SecHW.SupTemp	HW SUPPLY TEMP	LAI	Value	0.0.17				YES	78.3	78.7			
D3HQ.HWP1.SS	HW PUMP 1	L2SL	On/Off	0.0.28				NO	ON/OFF	ON/OFF			
D3HQ.HWP1.SS	HW PUMP 1	L2SL	Proof	0.0.4				YES	ON/OFF	ON/OFF			
D3HQ.HWP2.SS	HW PUMP 2	L2SL	On/Off	0.0.29				NO	ON/OFF	ON/OFF			
D3HQ.HWP2.SS	HW PUMP 2	L2SL	Proof	0.0.5				YES	ON/OFF	ON/OFF			
D3HQ.EF14.SS	EF14 ENABLE	L2SL	On/Off	0.0.30				NO	ON/OFF	ON/OFF			
D3HQ.EF14.SS	EF14 ENABLE	L2SL	Proof	0.0.8	OK	OK	N/A	YES	ON/OFF	ON/OFF	OK	12/5/08	OK

Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project:California Transportation District 3 HQ

MEC -02					Siemens Acceptance								
Point Name	Point Description	Point Type	Point Function	Address	Proper Installation	Point To Point	Procedure Number	Alarm Status	Displayed Value	Actual Value	Accepted	Date	Accepted By
D3HQ.CT1.VLV2	CT1 ISO VLV 2	L2SL	On/Off	0.0.28			4	NO	open/close	open/close		8 AUG 08	
D3HQ.CT1.VLV2	CT1 ISO VLV 2	L2SL	Proof	0.0.4				YES					
D3HQ.CT2.VLV2	CT2 ISO VLV 2	L2SL	On/Off	0.0.30				NO					
D3HQ.CT2.VLV2	CT2 ISO VLV 2	L2SL	Proof	0.0.6				YES					
D3HQ.CT1.VLV1	CT1 ISO VLV 1	L2SL	On/Off	0.0.27				NO					
D3HQ.CT1.VLV1	CT1 ISO VLV 1	L2SL	Proof	0.0.3				YES					
D3HQ.CT2.VLV1	CT2 ISO VLV 1	L2SL	On/Off	0.0.29				NO					
D3HQ.CT2.VLV1	CT2 ISO VLV 1	L2SL	Proof	0.0.5				YES	open/close	open/close			
D3HQ.EF01.SS	EF01 ENABLE	L2SL	On/Off	0.2.9				NO	on/off	on/off			
D3HQ.EF01.SS	EF01 ENABLE	L2SL	Proof	0.2.4				YES	on/off			8 AUG 08	
D3HQ.EF13.SS	EF13 ENABLE	L2SL	On/Off	0.2.11				NO				16 AUG 08	
D3HQ.EF13.SS	EF13 ENABLE	L2SL	Proof	0.2.6				YES					
D3HQ.EF15.SS	EF15 ENABLE	L2SL	On/Off	0.2.12				NO					
D3HQ.EF15.SS	EF15 ENABLE	L2SL	Proof	0.2.7				YES					
D3HQ.EF018.SS	EF02 ENABLE	L2SL	On/Off	0.2.10				NO					
D3HQ.EF018.SS	EF02 ENABLE	L2SL	Proof	0.2.5			4	YES	on/off	on/off		16 AUG 08	

Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project:California Transportation District 3 HQ

MEC -02					Siemens Acceptance								
Point Name	Point Description	Point Type	Point Function	Address	Proper Installation	Point To Point	Procedure Number	Alarm Status	Displayed Value	Actual Value	Accepted	Date	Accepted By
D3HQ.CT1.Fault	CT1 Fault	LDI	Status	0.1.5	[illegible]	[illegible]	N/A	YES	OFF	OFF	[illegible]	8-26-08	[illegible]
D3HQ.CT2.Fault	CT2 Fault	LDI	Status	0.1.6				YES					
D3HQ.CWP2.Fault	CW PUMP 2 Fault	LDI	Status	0.1.8									
D3HQ.CWP1.Fault	CW PUMP 1 Fault	LDI	Status	0.1.7									
D3HQ.CWP3.Fault	CW PUMP 3 Fault	LDI	Status	0.2.1									
D3HQ.CWP4.Fault	CW PUMP 4 Fault	LDI	Status	0.2.2									
D3HQ.CWP5.Fault	CW PUMP 5 Fault	LDI	Status	0.2.2									
D3HQ.CWP6.Fault	CW PUMP 6 Fault	LDI	Status	0.2.3				YES	OFF	OFF			
D3HQ.CT1.Speed	CT1 SPEED	LAO	Value	0.0.9				NO	28%	28%			
D3HQ.CT2.Speed	CT2 SPEED	LAO	Value	0.0.10					0	0			
D3HQ.CWP1.Speed	CWP1 SPEED	LAO	Value	0.0.11					0	0			
D3HQ.CWP2.Speed	CWP2 SPEED	LAO	Value	0.0.12					0	0			
D3HQ.CWP3.Speed	CWP3 SPEED	LAO	Value	0.0.13					29%	32%			
D3HQ.CWP4.Speed	CWP4 SPEED	LAO	Value	0.0.14					0	0			
D3HQ.CWP5.Speed	CWP5 SPEED	LAO	Value	0.0.15					0	0			
D3HQ.CWP6.Speed	CWP6 SPEED	LAO	Value	0.0.16				NO	30%	28%			
D3HQ.CT2.SupTemp	CT2 ~~RETURN~~ TEMP	LAI	Value	0.0.18				YES	74°	73.7			
D3HQ.CT1.SupTemp	CT1 ~~SUPPLY~~ TEMP	LAI	Value	0.0.17				YES	73°	72.7			
D3HQ.CW.EOLDP	END OF LINE DP	LAI	Value	0.3.1				NO	16.5	16.7			
D3HQ.CW.SupTemp	CW SUPPLY TEMP	LAI	Value	0.0.21				YES	71.2	71.6			
D3HQ.CW.RetTemp	CW RETURN TEMP	LAI	Value	0.0.22				YES	74.7	75.1			
D3HQ.OAHumid	OA Humid	LAI	Value	0.3.3					41%	40.3%			
D3HQ.OATemp	OA Temp	LAI	Value	0.3.2					81°	82.3°			
D3HQ.CT.SupTemp	CT SUPPLY TEMP	LAI	Value	0.0.19					74.7	74.1			
D3HQ.CT.Flow	CT SUPPLY FLOW	LAI	Value	0.0.23					3216PM	3306PM			
D3HQ.CW.Flow	CW SUPPLY FLOW	LAI	Value	0.0.24					3496PM	3526PM			
D3HQ.CT.RetTemp	CT RETURN TEMP	LAI	Value	0.0.20					76.2	76.3			
D3HQ.CWP2.SS	CW PUMP 2	L2SL	On/Off	0.0.32				NO	ON/OFF	ON/OFF			
D3HQ.CWP2.SS	CW PUMP 2	L2SL	Proof	0.0.8				YES					
D3HQ.CWP1.SS	CW PUMP 1	L2SL	On/Off	0.0.31				NO					
D3HQ.CWP1.SS	CW PUMP 1	L2SL	Proof	0.0.7				YES					
D3HQ.CWP3.SS	CW PUMP 3	L2SL	On/Off	0.1.9				NO					
D3HQ.CWP3.SS	CW PUMP 3	L2SL	Proof	0.1.1				YES					
D3HQ.CWP4.SS	CW PUMP 4	L2SL	On/Off	0.1.10				NO					
D3HQ.CWP4.SS	CW PUMP 4	L2SL	Proof	0.1.2				YES					
D3HQ.CWP5.SS	CW PUMP 5	L2SL	On/Off	0.1.11				NO					
D3HQ.CWP5.SS	CW PUMP 5	L2SL	Proof	0.1.3				YES					
D3HQ.CWP6.SS	CW PUMP 6	L2SL	On/Off	0.1.12				NO					
D3HQ.CWP6.SS	CW PUMP 6	L2SL	Proof	0.1.4				YES					
D3HQ.CT1.SS	COOLING TOWER 1	L2SL	On/Off	0.0.25				NO					
D3HQ.CT1.SS	COOLING TOWER 1	L2SL	Proof	0.0.1				YES					
D3HQ.CT2.SS	COOLING TOWER 2	L2SL	On/Off	0.0.26				NO					
D3HQ.CT2.SS	COOLING TOWER 2	L2SL	Proof	0.0.2	[illegible]	[illegible]	N/A	YES	ON/OFF	ON/OFF	[illegible]	8-26-08	[illegible]

Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: California Transportation District 3 HQ

MEC -03					Siemens Acceptance								
Point Name	Point Description	Point Type	Point Function	Address	Proper Installation	Point To Point	Procedure Number	Alarm Status	Displayed Value	Actual Value	Accepted	Date	Accepted By
D3HQ.AC4.Rm175.CO2	Room 175 CO2	LAI	Value	0.0.17	[illegible]	[illegible]	N/A	YES	327	340	[illegible]	10 AUG 2008	[illegible]
D3HQ.AC4.Rm230.CO2	Room 230 CO2	LAI	Value	0.0.19				YES	380	368			
D3HQ.AC4.Rm180.CO2	Room 180 CO2	LAI	Value	0.0.18				YES	260	263			
D3HQ.EF05.SS	EF05 ENABLE	L2SL	On/Off	1.30.2				NO	OFF/ON	OFF/ON			
D3HQ.EF05.SS	EF05 ENABLE	L2SL	Proof	1.30.10				YES	OFF/ON	OFF/ON			
D3HQ.EF10.SS	EF10 ENABLE	L2SL	On/Off	0.0.26				NO	OFF/ON	OFF/ON			
D3HQ.EF10.SS	EF10 ENABLE	L2SL	Proof	0.0.2				YES	OFF/ON	OFF/ON			
D3HQ.EF11.SS	EF11 ENABLE	L2SL	On/Off	0.0.27				NO	OFF/ON	OFF/ON			
D3HQ.EF11.SS	EF11 ENABLE	L2SL	Proof	0.0.3				YES	OFF/ON	OFF/ON			
D3HQ.EF17.SS	EF17 ENABLE	L2SL	On/Off	1.30.4				NO	OFF/ON	OFF/ON			
D3HQ.EF17.SS	EF17 ENABLE	L2SL	Proof	1.30.12				YES	OFF/ON	OFF/ON			
D3HQ.EF03.SS	EF03 ENABLE	L2SL	On/Off	1.30.1				NO	OFF/ON	OFF/ON			
D3HQ.EF03.SS	EF03 ENABLE	L2SL	Proof	1.30.9				YES	OFF/ON	OFF/ON			
D3HQ.EF16.SS	EF16 ENABLE	L2SL	On/Off	1.30.3				NO	OFF/ON	OFF/ON			
D3HQ.EF16.SS	EF16 ENABLE	L2SL	Proof	1.30.11				YES	OFF/ON	OFF/ON			
D3HQ.FIRE.PROOF	Fire Alarm	LDI	Proof	0.0.4				YES	OFF	OFF			
D3HQ.EMERGENCY	Emergency Power	LDI	Proof	1.30.2	[illegible]	[illegible]	N/A	YES	OFF	OFF	[illegible]	10 AUG 2008	[illegible]

Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: California Transportation District 3 HQ

MEC -04					Siemens Acceptance								
Point Name	Point Description	Point Type	Point Function	Address	Proper Installation	Point To Point	Procedure Number	Alarm Status	Displayed Value	Actual Value	Accepted	Date	Accepted By
D3HQ.EF02.SS	EF02 ENABLE	L2SL	On/Off	0.0.1	[illegible]	[illegible]	n/a	NO	ON/OFF	ON/OFF	[illegible]	21JUL08	[illegible]
D3HQ.CRAC.DryCoolerPump2	PUMP 2	LDI	On/Off	0.0.3				YES	ON/OFF	ON/OFF			
D3HQ.CRAC.DryCooler2	DryCooler2	LDO	On/Off	0.0.28				YES	ON/OFF	ON/OFF			
D3HQ.CRAC.DryCooler1	DryCooler1	LDO	On/Off	0.0.29				YES	ON/OFF	ON/OFF			
D3HQ.CRAC.DryCoolerVlv1	DryCooler Vlv1	LDO	~~Status~~ Operate	0.0.30				NO	OPEN/CLOSE	OPEN/CLOSE			
D3HQ.CRAC.DryCoolerVlv2	DryCooler Vlv2	LDO	~~Value~~ Operate	0.0.31				NO	OPEN/CLOSE	OPEN/CLOSE			
D3HQ.CRAC.CWSupTemp	CW SUPPLY TEMP	LAI	On/Off	0.0.17				YES	78.7	78.9			
D3HQ.CRAC.NormalPowerAvail	Norm Power Avail	LDI	Proof	0.0.4	Changed to MEC 03 point emergency power								
D3HQ.CRAC.FLOW	FLOW SW ON	LDI	On/Off	0.0.5				YES	FLOW/NOFLOW	FLOW/NOFLOW			
D3HQ.CRAC.DryCoolerPump1	PUMP STATUS	LDI	Proof	0.0.2	[illegible]	[illegible]	n/a	YES	FLOW/NOFLOW	FLOW/NOFLOW	[illegible]	21JUL08	[illegible]

Siemens Building Technologies, Inc.
Commissioning Summary Sheets
Project: California Transportation District 3 Headquarters

MEC -05					Siemens Acceptance								
Point Name	Point Description	Point Type	Point Function	Address	Proper Installation	Point To Point	Procedure Number	Alarm Status	Displayed Value	Actual Value	Accepted	Date	Accepted By
D3HQ.AC1.Rm105.CO2	Room 105 CO2	LAI	Value	0.0.17	[illegible]	[illegible]		Y	220	220	[illegible]	23Jul408	[illegible]
D3HQ.AC1.Rm106.CO2	Room 106 CO2	LAI	Value	0.0.18		[illegible]		Y	230	230			
D3HQ.AC1.Rm505.CO2	Room 505 CO2	LAI	Value	0.0.19	[illegible]	[illegible]		Y	240	240	[illegible]	23Jul408	[illegible]

SIEMENS

Project Name: CalTrns District 3 H,Q.	Project #: 44OP-0183-57

MEC#: 01	Node Name: D3HQ.MEC01

Initial	Check where indicated:	
	1	**Install all hardware per the installation instructions and verify:**
	✓	Power
	✓	Controller /Expansion Module
	✓	Point Expansion Modules (if present)
	✓	120 VAC to 24 VAC Power Supply
	✓	Verify environmental conditions are within Siemens Specifications.

Initial	Check where indicated:	
	2	**Insure MEC power is available (between 102 to 132 VAC) and test for ground, measure at the receptacle:**
	✓	Record the AC Voltage 119.6 VAC
	✓	Is the ground wired correct? (grounding from conduit is not acceptable (Y/N)____.
	✓	If Yes proceed to step (3). If No have the electrician rewire the outlet.

Initial	Check where indicated:	
	3	**Insure all point wiring terminations are securely connected and wiring is labeled as per panel drawings:**
	✓	After verifying the termination wiring and wire labels, correct any discrepancies.

Initial	Check where indicated:	
	4	**Power up the MEC and verify (BST) Basic Sanity Test LED:**
	✓	If the (BST) LED is flashing proceed to step (6). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	5	**Enable the controller battery by removing the mylar separator:**
	✓	If the low battery LED is not lit proceed to step (7). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	6	**Connect a laptop to the MMI port of the controller module. Set your comm. port to 9600 BPS (MEC factory default). The command prompt should appear after depressing <ENTER>.**
	✓	If the command prompt appears proceed to step (8). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	7	**Log "ON" to the MEC, select system, hardware, field panels, configure, address. Select set node address per network configuration layout. Select 'Y' and:**
	✓	Set Network baud to 115200 Baud. Record network setup parameters.

Initial	Check where indicated:	
	8	**Connect the MEC node to network table. (MEC Cabinet Start-up).**
	✓	MEC Cabinet Start-up is complete. Sign, date and proceed to Point Check-out procedures.

Initial	Check where indicated:	
	9	**Check conformity of the following:**
	✓	Security (Lock and keys are available and functioning).
	✓	Enclosure and Component specifications match the specified.
	✓	Visual Inspection (Fit and Finish).

Siemens' Representative	
Name:	Todd T. Osmon
Title:	SYSTEM SPECIALIST II
Signature:	
Date:	4 AUG 2008

Project Name: CalTrns District 3 H,Q.	Project #: 44OP-0183-57

MEC#: 02	Node Name: D3HQ.MEC02

Initial	*Check where indicated:*	
	1	**Install all hardware per the installation instructions and verify:**
	✓	Power
	✓	Controller /Expansion Module
	✓	Point Expansion Modules (if present)
	✓	120 VAC to 24 VAC Power Supply
	✓	Verify environmental conditions are within Siemens Specifications.

Initial	*Check where indicated:*	
	2	**Insure MEC power is available (between 102 to 132 VAC) and test for ground, measure at the receptacle:**
	✓	Record the AC Voltage 121.5.
	✓	Is the ground wired correct? (grounding from conduit is not acceptable (Y/N)____.
	✓	If Yes proceed to step (3). If No have the electrician rewire the outlet.

Initial	*Check where indicated:*	
	3	**Insure all point wiring terminations are securely connected and wiring is labeled as per panel drawings:**
	✓	After verifying the termination wiring and wire labels, correct any discrepancies.

Initial	*Check where indicated:*	
	4	**Power up the MEC and verify (BST) Basic Sanity Test LED:**
	✓	If the (BST) LED is flashing proceed to step (6). Otherwise record and resolve the problem.

Initial	*Check where indicated:*	
	5	**Enable the controller battery by removing the mylar separator:**
	✓	If the low battery LED is not lit proceed to step (7). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	6	**Connect a laptop to the MMI port of the controller module. Set your comm. port to 9600 BPS (MEC factory default). The command prompt should appear after depressing <ENTER>.**
	✓	If the command prompt appears proceed to step (8). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	7	**Log "ON" to the MEC, select system, hardware, field panels, configure, address. Select set node address per network configuration layout. Select 'Y' and:**
	✓	Set Network baud to 115200 Baud. Record network setup parameters.

Initial	Check where indicated:	
	8	**Connect the MEC node to network table. (MEC Cabinet Start-up).**
	✓	MEC Cabinet Start-up is complete. Sign, date and proceed to Point Check-out procedures.

Initial	Check where indicated:	
	9	**Check conformity of the following:**
	✓	Security (Lock and keys are available and functioning).
	✓	Enclosure and Component specifications match the specified.
	✓	Visual Inspection (Fit and Finish).

Siemens' Representative	
Name:	Todd Osmer
Title:	System Specialist II
Signature:	
Date:	4 AUG 2008

Initial	Check where indicated:	
	6	**Connect a laptop to the MMI port of the controller module. Set your comm. port to 9600 BPS (MEC factory default). The command prompt should appear after depressing <ENTER>.**
	✓	If the command prompt appears proceed to step (8). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	7	**Log "ON" to the MEC, select system, hardware, field panels, configure, address. Select set node address per network configuration layout. Select 'Y' and:**
	✓	Set Network baud to 115200 Baud. Record network setup parameters.

Initial	Check where indicated:	
	8	**Connect the MEC node to network table. (MEC Cabinet Start-up).**
	✓	MEC Cabinet Start-up is complete. Sign, date and proceed to Point Check-out procedures.

Initial	Check where indicated:	
	9	**Check conformity of the following:**
	✓	Security (Lock and keys are available and functioning).
	✓	Enclosure and Component specifications match the specified.
	✓	Visual Inspection (Fit and Finish).

Siemens' Representative	
Name:	Todd T. Osmun
Title:	SPECIALIST II
Signature:	
Date:	4 AUG 2008

Project Name: CalTrns District 3 H,Q.	Project #: 44OP-0183-57
MEC#: 03	Node Name: D3HQ.MEC03

Initial	*Check where indicated:*	
	1	**Install all hardware per the installation instructions and verify:**
	✓	Power
	✓	Controller /Expansion Module
	✓	Point Expansion Modules (if present)
	✓	120 VAC to 24 VAC Power Supply
	✓	Verify environmental conditions are within Siemens Specifications.

Initial	*Check where indicated:*	
	2	**Insure MEC power is available (between 102 to 132 VAC) and test for ground, measure at the receptacle:**
	✓	Record the AC Voltage 121.3 VAC
	✓	Is the ground wired correct? (grounding from conduit is not acceptable (Y/N) Y.
	✓	If Yes proceed to step (3). If No have the electrician rewire the outlet.

Initial	*Check where indicated:*	
	3	**Insure all point wiring terminations are securely connected and wiring is labeled as per panel drawings:**
	✓	After verifying the termination wiring and wire labels, correct any discrepancies.

Initial	*Check where indicated:*	
	4	**Power up the MEC and verify (BST) Basic Sanity Test LED:**
	✓	If the (BST) LED is flashing proceed to step (6). Otherwise record and resolve the problem.

Initial	*Check where indicated:*	
	5	**Enable the controller battery by removing the mylar separator:**
	✓	If the low battery LED is not lit proceed to step (7). Otherwise record and resolve the problem.

SIEMENS

Project Name: CalTrns District 3 H,Q.	Project #: 44OP-0183-57

MEC#: 05	Node Name: D3HQ.MEC05

Initial	Check where indicated:	
	1	**Install all hardware per the installation instructions and verify:**
	✓	Power
	✓	Controller /Expansion Module
	✓	Point Expansion Modules (if present)
	✓	120 VAC to 24 VAC Power Supply
	✓	Verify environmental conditions are within Siemens Specifications.

Initial	Check where indicated:	
	2	**Insure MEC power is available (between 102 to 132 VAC) and test for ground, measure at the receptacle:**
	✓	Record the AC Voltage 121.6.
	✓	Is the ground wired correct? (grounding from conduit is not acceptable (Y/N) ___.
	✓	If Yes proceed to step (3). If No have the electrician rewire the outlet.

Initial	Check where indicated:	
	3	**Insure all point wiring terminations are securely connected and wiring is labeled as per panel drawings:**
	✓	After verifying the termination wiring and wire labels, correct any discrepancies.

Initial	Check where indicated:	
	4	**Power up the MEC and verify (BST) Basic Sanity Test LED:**
	✓	If the (BST) LED is flashing proceed to step (6). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	5	**Enable the controller battery by removing the mylar separator:**
	✓	If the low battery LED is not lit proceed to step (7). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	6	**Connect a laptop to the MMI port of the controller module. Set your comm. port to 9600 BPS (MEC factory default). The command prompt should appear after depressing <ENTER>.**
	✓	If the command prompt appears proceed to step (8). Otherwise record and resolve the problem.

Initial	Check where indicated:	
	7	**Log "ON" to the MEC, select system, hardware, field panels, configure, address. Select set node address per network configuration layout. Select 'Y' and:**
	✓	Set Network baud to 115200 Baud. Record network setup parameters.

Initial	Check where indicated:	
	8	**Connect the MEC node to network table. (MEC Cabinet Start-up).**
	✓	MEC Cabinet Start-up is complete. Sign, date and proceed to Point Check-out procedures.

Initial	Check where indicated:	
	9	**Check conformity of the following:**
	✓	Security (Lock and keys are available and functioning).
	✓	Enclosure and Component specifications match the specified.
	✓	Visual Inspection (Fit and Finish).

Siemens' Representative	
Name:	Todd T. Osmon
Title:	SYSTEM SPECIALIST II
Signature:	
Date:	4 AUG 2008

9.0 Functional Performance Test Plan and Results

This section contains completed FPT forms used to test mechanical, electrical, lighting & control systems at this facility. The FPTs in this section were created based on sequences of operation and were used to verify intended operation of the systems mentioned below. The contractor(s) and commissioning agent (CxA) performed the hardware and/or software manipulations required to perform the tests. Test procedures were witnessed and observations recorded by the CxA and other commissioning team members.

The benefits usually associated with Functional Performance Testing include energy and resource savings, greater reliability as well as improved IAQ.

Up to this point, some the functional performance tests had been completed – refer to attached e-mail - due to system operation issues. It has been agreed that BPM, operation & maintenance personnel, will continue with the functional performance testing after all major issues have been resolved. CxA will provide necessary assistance to BPM in facilitating the process.

Alex Ho - Caltrans District 3, Marysville - Progress in FPTs for DGS Project

From: Alex Ho
To: Derek Kmicikiewicz
Date: 7/7/2009 10:21 AM
Subject: Caltrans District 3, Marysville - Progress in FPTs for DGS Project
CC: Shane Mason
Attachments: Deficiencies Report 081126.pdf

Dear Derek

We had conducted filed Cx for 3 days on November 20, 21 and 25, 2008.

Progress in functional performance testing for systems to be commissioned (last updated on Nov 26th, 08):
1. Condensing Water (CW) System - 100%
2. Heating Hot Water (HHW) System - 100%
3. Rooftop Air Handling Units - 100%*
4. VAV Boxes - 0% (graphical screen not in place)
5. CRAC Units - 0% (MC and CC still working on integrating the local CRAC Management System into the Siemens Control System)
6. Makeup Air Unit and Kitchen Exhaust Fan - 100%
7. General Exhaust Fans - 0% (graphical screen not in place)
8. Water Source Heat Pump Unit (PCUs) - 0% (graphical screen not in place)
9. Building Automation System - 0% (graphical user interface not complete)
10. Lighting Control Systems - 0% (front end laptop computer not available)
11. Domestic Hot Water (DHW) System - 0% (Sequence of Operation missing)

Remark:
* Owner's operation personnel reported that there was an building pressure control problem with the Petra RTUs - still unresolved up till now.

Attached the Issues Log dated November 26, 2008 for your reference.

Regards

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Please consider the environment before printing this E-mail.

Functional Performance Testing Procedure

System:	Cendenser Water System
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps
Equipment Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6

Participants:	**Name**	**Organization**
Date: 11/21/08	Alex Ho	AEC
	John Arent	AEC
	Gary	Siemens
	Kevin Kiley	ACCO
	Rich	BPM

Comments:

Sequence:

Cooling Tower and Tower Loop Pumps - TOWER LOOP
Two (2) open cooling towers provide condenser water pumped through the tower loop side of the plate heat exchanger by condenser water pumps with VFDs. The cooling towers are complete with vibration switches and VFDs. Additional condenser water pumps with VFDs circulate the building loop water through the plate heat exchanger and the building systems, including the rooftop AC units, CRACs, and water-source heat pumps (PCUs).
This system will have a low load condition during off hours (when the AC units are off) and during the winter (when the AC units satisfy their cooling requirements with economizer operation only). Low load condenser water pumps, on both the tower loop and building loop, provide low flow when required. Since this system serves CRAC units and water-source heat pumps (PCUs) that operate 24/7/365, this system is always enabled and operation (when normal power is available).

Staging Control
There are 2 stages of cooling in the sequence. Stage 1 Cooling is for low CW loads. Stage 1 Cooling uses only the small CW pump (CWP-3) and the lead cooling tower. Stage 2 Cooling is for moderate to maximum CW loads. Stage 2 Cooling uses both large CW pumps (CWP-1 and CWP-2) and both cooling towers. The cooling tower system is staged to maintain a condenser water supply temperature to setpoint (variable - 65 to 80 deg. F). Please refer to the attached "Cooling Tower Load Sequencing" for additional details on how the equipment is sequenced to maintain the supply temperature to setpoint.
When Stage 1 is active and Stage 1 is at maximum cooling and the CW supply temperature is greater than setpoint for 5 minutes, Stage 2 cooling is started.
When Stage 2 is active and Stage 2 is at minimum cooling and the CW supply temperature is less than setpoint for 15 minutes, Stage 1 cooling is started.

Condenser Water Supply Temperature Setpoint Optimization
Cooling Towers are limited in their cooling capacity by the outdoor air wetbulb temperature. The condenser water supply temperature setpoint is optimized to provide the coldest possible CW (low limit of 65 deg. F) without wasting energy due to OA wetbulb limitations. When the outdoor air wetbulb temperature is lower than 55 deg. F, the condenser water supply temperature setpoint is 65 deg. F. As the outdoor air wetbulb temperature rises above 55 deg. F, the condenser water supply temperature setpoint is reset to be the outdoor air wetbulb temperature plus 10 deg. F (high limit of 80 deg. F).

Lead/Lag/Standby Rotation: Lead/Lag rotation of the cooling towers occurs monthly.

Condenser Water Pumps - BUILDING LOOP
(2) 50% duty variable speed Condenser Water Pumps (CWP-4, 5) and (1) low-load variable speed constant water pump (CWP-6) are arranged in parallel serving a common header. The pumps are staged and modulate in speed to maintain the building CW differential pressure to setpoint.

Pump Failure
If a CWP fails to start when commanded on by the BAS, an alarm is generated and the next pump in the sequence is started.

Functional Performance Testing Procedure

System:	Cendenser Water System
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps
Equipment Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6

Building Loop Differential Pressure Control

CWP-6 is always the lead pump (used for low loads) and CWP-4 and CWP-5 alternate as Lag1 and Lag2 pumps. The building loop condenser water pump VFDs operate to maintain a differential pressure to setpoint (initially 5 psig). CWP-6 is started and modulates in speed to maintain differential pressure to setpoint.

When CWP-6 is at 100% speed for 2 minutes, CWP-6 is stopped and the Lag1 CWP is started. The Lag1 pump modulates in speed from minimum to maximum.

When the Lag1 pump is at 100% speed for 2 minutes, the Lag2 pump is started. Both the Lag1 and Lag2 pumps modulate at the same speed from minimum to maximum.

When the Lag1 and Lag2 pumps are less than 62% speed for 10 minutes, the Lag2 pump is stopped.

When the Lag1 pump is less than 62% speed for 10 minutes. the Lag1 pump is stopped and CWP-6 is started.

Alarms

The following alarm points are monitored by the BAS:

1. VFD General Alarm
2. Cooling Tower Isolation Valve end switches
3. Condenser Water high /low limit
4. Pump status

Emergency Power Mode

Upon loss of Normal Power, CT-2 is disabled and CT-1 is allowed to operate.

The control valves for CT-1 open and the control valves for CT-2 close. Cooling is switched to Stage 1.

CWP-1, 2 shut down and CWP-3 continues to operate.

CWP-4, 5 shut down and CWP-6 continues to operate.

Events	1: Startup/Shutdown 2: Occupied Mode 3: Temperature Reset 4: Safeties/Alarms

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS
CW supply Temp (F)	
CW return Temp (F)	
Diff. Pressure Sensor (Psi)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
CWS Temp		
CWR Temp		
DP Sensor		

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
CT-1 Iso Valve				
CT-2 Iso Valve				

Functional Performance Test

System:	Cendenser Water System
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps
Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	1	**Startup/Shutdown** Verify that the system can be operated in each of the three modes listed below, 1. Based on the time schedule 2. Manually override from BAS	System turns ON and OFF in accordance with time clock. It responses to override from BAS, and reset to original operation mode after the override is removed.	override equipment one by one
☐	☐	2 a	**Occupied Mode: Low Flow Condition** With CW system in unoccupied mode, override supply CW temp. to be within deadband and time clock be 5 minutes before occupancy	Lead SCWP starts and runs at Min. speed. Lead CT is enabled, Iso valve opens and fan OFF. Lag CT is disabled, Iso valve is closed and fan OFF. Lead PCWP starts and runs at 100% speed. All lag CWPs are OFF.	Alex recommends adding speed of VFD to BAS Lead PCWP ramps down from 60Hz to 32 Hz as the lowest stage
☑	☐	2 b	**Tower Loop Stage 1 ON** With CW system in occupied mode, override supply CW temp. to be above setpt	Lead SCWP and lead PCWP run continuously. All lag CWPs are OFF. Lag CT is disabled. Lead CT fan modulates between Min. & Max. to maintain supply CW temp. at setpt.	Lead SCWP depends on Flow -- >100gpm -- P4, <100gpm -- P6
☑	☐	2 c	**Tower Loop Stage 2 ON** With Tower Loop at Stage 1 maximum, override supply CW temp. to be above setpt and wait for 10 minutes	Lead SCWP runs continuously. Lag SCWPs are OFF. ✓ Lead PCWP shuts down and lag 1 PCWP turns on. ✓ Lag CT is enabled and Iso valve opens. Lead & lag CT fans and Lag 1 & 2 PCWPs modulates between Min. & Max. to maintain supply CW temp. at setpt.	Lag 1 PCWP enough gpm for both towers
☑	☐	2 d	**Tower Loop Stage 2 OFF** With Tower Loop at Stage 2 minimum, override supply CW temp. to be below setpt and wait for 10 minutes	Lead SCWP runs continuously. Lag SCWPs are OFF. Lag 1 PCWP shuts down and lead PCWP turns on. Lag CT fan OFF, Iso valve closes and is disabled. Lead CT fan modulates between Min. & Max. to maintain supply CW temp. at setpt.	Tower 2 stages off after at min fan 15Hz

Functional Performance Test

System:	Cendenser Water System
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps
Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	2 e	**Building Loop 1st Stage ON** With CW system in occupied mode, override CW diff.pressure to be below setpt + GPM	Lead PCWP and lead CT fan run continuously. Lag PCWPs are OFF. Lag CT is disabled. Lead SCWP shuts down and lag 1 SCWP turns on. Lag 1 SCWP modulates to maintain CW diff. pressure to be at setpt.	~~Lead and lag SCWP run together.~~
☑	☐	2 f	**Building Loop 2nd Stage ON** With Lag 1 SCWP is running, override CW diff.pressure to be below setpt	Lead PCWP and lead CT fan run continuously. Lag PCWPs are OFF. Lag CT is disabled. Lag 1 SCWP ramps to 100% speed. Lag 2 SCWP starts after 5 mins. Lag 1 & 2 SCWPs run in unison and modulate to maintain CW diff. pressure to be at setpt.	2 CTs 1 large CWP
☑	☐	2 g	**Building Loop 2nd Stage OFF** With Lag 1 & 2 SCWPs are running, override CW diff.pressure to be above setpt and wait for 15 mins	Lead PCWP and lead CT fan run continuously. Lag PCWPs are OFF. Lag CT is disabled. Lag SCWPs ramp down and Lag 2 SCWP shuts down after 10 mins. Lag 1 SCWP ramp up and modulate to maintain CW diff. pressure to be at setpt.	
☑	☐	3	**Supply CW Temp Reset** With CW system in occupied mode, override OA wetbulb temp to be 5 deg. F above the actual value	CW supply temp setpt automatically adjusted to OA wetbulb temp plus 10 deg. F or the max. value of 80 deg. F. CW system stages ON to increase the rate of heat rejection.	Need to trend
☐	☐	4 a	**Cooling Tower Alarm:** With lead CT is ON, override CT status to be OFF	Lead CT shuts down and lag CT turns ON. An alarm is generated at the BAS.	Ledge alarm for fan will be added
☐	☐	4 b	**Primary CW Pump Alarm (CWP-1 to 3)** With lead PCWP is running, override CW pump status to be OFF	Lead CW pump shuts down and lag CW pump turns ON. An alarm is generated at the BAS.	Alarm but no fail over (N/A)
☑	☐	4 c	**Secondary CW Pump Alarm (CWP-4 to 6)** With lead SCWP is running, override CW pump status to be OFF	Lead CW pump shuts down and lag CW pump turns ON. An alarm is generated at the BAS.	CW pump 6 shows alarm in yellow
☐	☐	4 d	**CW System Alarm:** With CW system in operation, override system status to be unoccupied	CRAC units switches to 'Bypass' mode and Drycoolers are enabled. CW system shut down and an alarm is generated at the BAS.	To be tested during CRAC FPTs

Cooling Tower (Tower Loop) Load Sequencing of Caltrans - Marysville

Tower CW Load	Ultra Min	Stage 1			Stage 2			
		Min	**Mid**	**Max** (MAX 2)	**Min**	**33%**	**66%**	**Max**
Lead Tower Iso Valves	open	Open	Open	Open	Open	Open	Open	Open
Lead Tower Fans	off	Off	On – 25%	On – 100%	On – 25%	On – 50%	On – 50%	On – 100%
Lag Tower Iso Valves	C	Closed	Closed	Closed	Open	Open	Open	Open
Lag Tower Fans	OFF	Off	Off	Off	On – 25%	On – 50%	On – 50%	On – 100%
Lead Tower CWP (Always CWP-3)	ON 32%	On – ~~100%~~ 50	On – ~~100%~~ 50	On – ~~100%~~ 50 100	Off	Off	Off	Off
Lag1 Tower CWP (Primary Loop)	OFF	Off	Off	Off	On – 50%	On – 50%	On – 100%	On – 100%
Lag2 Tower CWP (Primary Loop)	OFF	Off	Off	Off	On – 50%	On – 50%	On – 100%	On – 100%

CT Stage Down Seq.

1. PCWP 60Hz → 40Hz
2. CT Fan to 15Hz
3. CT Fan off
4. PCWP 40Hz → 30-32Hz

Functional Performance Testing Procedure

System:	Heating Hot Water System	
Title:	Three Boilers w/ circulating pumps and two HW pumps	
Equipment Tag:	B-1, B-2, B-3, HWP-1 & HWP-2	
Participants:	**Name**	**Organization**
	Derek	AEC
	Alex Ho	AEC
Date: 11/25/08	Todd	Siemens
	Kevin Kiley	ACCO
	Rich	BPM
Comments:		

Sequence:

General:
This system is controlled by the Siemens BAS. The primary/secondary hot water system consists of three (3) boilers with integral primary pumps-including one 50% backup boiler-and two hot water secondary pumps with VFDs. The hot water system circulates secondary hot water generated by the boilers to AC Unit preheat coils and VAV hot water reheat coils.
Two (2) Secondary Hot Water Pumps (SHWP) are arranged in parallel serving a common header. Each pump is provided with a variable frequency drive (VFD). Hot water from the secondary hot water loop is circulated to the AC units on the roofs and VAV reheat coils on all floors.

Hot Water Setpoint: The hot water system shall maintain 180 deg.F supply water in the primary loop. No hot water temperature reset is provided.

Heating Hot Water System (Primary Loop)

Occupied Start/Stop (normal building hours)
The hot water system is enabled by the BAS when a request for heating is generated by four or more VAV hot water reheat coils or one or more AC unit preheat coils. The hot water system is disabled by the BAS when a request for heating is generated by two or less VAV hot water reheat coils and no AC unit preheat coils. When the hot water system is enabled, the factory mounted local controller on the lead boiler is commanded on. The local boiler controller provides local boiler control. When the primary HW supply temperature is less than 160 deg. F for 10 minutes, the lag boiler is enabled by the BAS. When the primary HW supply temperature is greater than 175 deg. F and the primary HW differential temperature is less than 10 deg. F for 20 minutes, the lag boiler is disabled by the BAS.

Lead/Lag Rotation: Lead/Lag rotation of the Boilers occurs monthly.

Unoccupied Night Heating, Warm-Up, Override Modes
Upon call for Night Heating, Morning Warm-Up, or activation of AC unit Override during unoccupied hours, the hot water system switches to normal building hour operation for the duration of the mode. With no call for Night Heating, Morning Warm-Up, nor activation of AC unit Override during unoccupied hours, the hot water system is disabled.

Boiler Failure: If the lead Boiler fails to start, an alarm is generated by the BAS. The lead boiler is locked out and the lag Boiler becomes the lead Boiler. The backup boiler becomes the lag boiler.

Secondary Hot Water Pumps

Start/Stop (normal building hours)
The lead hot water pump (HWP-1 or HWP-2) starts at minimum speed after the hot water system is enabled. The lead hot water pump VFD modulates to maintain the differential pressure setpoint in the secondary hot water loop. When differential pressure setpoint falls below setpoint and the lead pump has been at 100% speed for 10 minutes, the lag hot water pump starts. When differential pressure setpoint is at setpoint and both pumps has been at less than 60% speed for 20 minutes, the lag hot water pump stops.

Functional Performance Testing Procedure

System:	Heating Hot Water System
Title:	Three Boilers w/ circulating pumps and two HW pumps
Equipment Tag:	B-1, B-2, B-3, HWP-1 & HWP-2
	Speed Control: Pump speed is modulated by the BAS to maintain a differential pressure of 5 psi (adj.) in the secondary hot water loop. Lead/Lag Rotation: Lead/Lag rotation of SHWP occurs monthly. Pump Failure: If a SHWP fails to start when commanded on by the BAS, an alarm is generated and the lag pump is started.
	Alarms The following alarm points are monitored by the BAS: 1. Boiler controller general alarm 2. Pump status **Emergency Power Mode** Upon loss of Normal Power, The BAS disables all boilers and pumps.
Events	1: Startup/Shutdown 2: Occupied Mode 3: Unoccupied Mode 4: Safeties/Alarms

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes

Status Check

Override control to each piece of equipment, note response.

Component	Responds?	Notes

Functional Performance Test

System:	Heating Hot Water System
Title:	Three Boilers w/ circulating pumps and two HW pumps
Tag:	B-1, B-2, B-3, HWP-1 & HWP-2

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	1	**Startup/Shutdown** Verify that the system can be operated in each of the three modes listed below, 1. Based on number of heat requests 2. Lockout due to high OA temperature 3. Manually override from BAS	System turns ON and OFF in accordance with the incoming heat requests. System will be lockout if the OAT in above 65 F. It responses to override from BAS, and reset to original operation mode after the override is removed.	Boiler Alarms stay on but boilers still can enable
☑	☐	2a	**Occupied Mode: No Heating** With HHW system in unoccupied mode, override supply HHW temp. to be within deadband and heat requests to be above setpoint	Lead HW pump ON. Lead boiler circulating pump turns ON and the lead boiler is enabled.	
☑	☐	2b	**Occupied Mode: Lag Pump Stage ON** With HHW system in occupied mode, override building HHW diff. pressure to be below setpt	Lead HW pump ramps up to full speed. After 10 minutes, lag HW pump turns ON. Lead and lag HW pumps run in unison sharing the same load.	
☑	☐	2c	**Occupied Mode: 1st Stage Heating** With HHW system in occupied mode, override supply HHW temp. to be below setpt ~~temp diff. 20°F~~	Lead HW pump runs continuously. Lead boiler turns ON and modulate to maintain boiler loop HHW temp. to be at setpoint.	
☑	☐	2d	**Occupied Mode: 2nd Stage ON** With lead boiler is ON, override supply HHW temp. to be below ~~160 deg.~~ F and wait for 10 minutes Supply diff. temp of higher than 20°F	Lead HW pump runs continuously. Lead boiler is ON. Lag boiler circulating pump turns ON. Lag boiler is enabled and then turns ON. Lead and lag boilers run in unison sharing the same load.	
☑	☐	2e	**Occupied Mode: 2nd Stage OFF** With lead and lag boiler is ON, override supply HHW temp. to be above 175 deg. F, HHW diff. temp to be ~~less~~ than 10 deg. F and wait for 20 minutes return	Lead HW pump runs continuously. Lead boiler is ON. Lag boiler turns OFF and is disabled. Lag boiler circulating pump turns OFF after 15 mins.	

Functional Performance Test

System:	Heating Hot Water System
Title:	Three Boilers w/ circulating pumps and two HW pumps
Tag:	B-1, B-2, B-3, HWP-1 & HWP-2

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	3a	**Unoccupied Night Heating Mode** With HHW system and building are in unoccupied mode, override building status to be night heating mode	HHW system starts and operates in the Occupied Mode.	
☑	☐	3b	**Unoccupied Morning Warm-up Mode** With HHW system and building are in unoccupied mode, override space temp to be below occupied htg setpt and time clock to be 30 minutes before occupancy	Morning warm-up sequence is enabled. HHW system starts and operates in the Occupied Mode.	
☑	☐	3c	**Freeze Protection Mode** With HHW system and building are in unoccupied mode, override OA temp to be below 45 deg. F	Heating coil control valves of AHUs open to minimum position. HHW system starts and operates in the Occupied Mode.	
☑	☐	4a	**Boiler Alarm:** With lead boiler is ON, override boiler status to be OFF	Lead boiler shuts down and lag boiler stages ON. An alarm is generated at the BAS.	
☑	☐	4b	**HW Pump Alarm:** With lead HW pump is running, override HW pump status to be OFF	Lead HW pump shuts down and lag HW pump stages ON. An alarm is generated at the BAS.	
☐	☐	4c	**High HHW Temp. Alarm:** With HHW system in occupied mode, override supply HHW temp. to be 20 deg. F above setpt and wait for 15 mins.	Boiler stages OFF and an alarm is generated at the BAS.	N/A
☑	☐	4d	**Low HHW Temp. Alarm:** With lead and lag boilers are in operation, override supply HHW temp. to be 20 deg. F below setpoint and wait for 15 mins.	Lead and lag boilers operate continuously and an alarm is generated at the BAS.	

Functional Performance Testing Procedure

System:	Central Variable Volume Air Handling Systems	
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer	
Equipment Tag:	AC-1, AC-2, AC-3, AC-4 & AC-5	
Participants:	**Name**	**Organization**
Date: 11/20/08	Alex Ho	AEC
	John Arent	AEC
	Gary	Siemens
	Kevin Kiley	ACCO
	Steve	Petra
	Rich	BPM
Comments:		

Sequence:

General:
The water-cooled rooftop direct expansion (DX) units (AC units) include high efficiency refrigeration, hot water preheat coils, supply and return or relief fans with variable frequency drives (VFDs), fully integrated economizers, outside air (OSA) monitoring stations (except AC-5), direct digital (DDC) controls and air filtration. Heat is rejected from the water-cooled condenser section to the cooling towers. These units have factory-installed ACL controllers with a Bacnet MSTP interface to the Siemens BAS.

Start/Stop:
The air handling unit is scheduled for automatic operation on a time of day basis for Occupied and Unoccupied modes. Within the Unoccupied mode, the system can enter Warm-Up mode when the space temperature is below setpoint or the Cool-Down mode when the space temperature is above setpoint, scheduled to initiate 1hour and 1-half before occupied mode to meet occupied setpoints. Within the Unoccupied mode, Night Heating and Night Cooling are available. Night Heating is available when the space temperature from three or more VAV zones with associated AC unit drops below 61 deg. F. Night Cooling is available when the space temperature from three or more VAV zones with associated AC unit increases above 82 deg. F. The latest start time is the scheduled occupancy for the space.

Warm-Up:
The AC-Unit is enabled and forced into Morning Warmup. The heating water system is enabled. The VAV boxes are set to heating mode and the VAV control dampers modulate to warm-up the space to the space day heating setpoint. Warm-Up mode ends when only two zones associated with the AC unit are 3 deg. F or less below the space day heating setpoint (70 deg. F), or when time reaches the scheduled occupancy during the Warm-Up mode. The VAV boxes control their own heating/cooling mode. The system is prevented from entering the Warm-Up mode during occupied hours.

Cool-Down:
This mode is enabled during Unoccupied Mode when the space is warm and the outdoor air is cool enough to cool the building using only economizer. The AC-Unit is enabled and Mechanical Cooling is locked out. The VAV control dampers modulate to cool-down the space to the space cooling setpoint. Cool-Down mode is enabled when the average space temperature is greater than the cooldown setpoint (initially 78 deg. F) and the outside air temperature is at least 10 deg. F colder than the average space temperature. This mode ends when the average space temperature is 5 deg. F less than the cooldown setpoint (initially 78 deg. F) or the outside air temperature is less than 5 deg. F colder than the average space temperature, or when time reaches the scheduled occupancy during the Cool-Down mode. The system is prevented from entering the Cool-Down mode during occupied hours.

Occupied:
The AC-Unit is enabled. During occupied mode, the VAV boxes control damper and the reheat coil control valves modulate to maintain the space setpoint.

Functional Performance Testing Procedure

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Equipment Tag:	AC-1, AC-2, AC-3, AC-4 & AC-5

Supply Air Temperature Setpoint
The supply temperature setpoint shall be reset from both the outdoor air temperature and the average zone temperature between the limits of 55-65 deg. F (adj.). The following matrix shall be used:

	OA Temp 30	60	90
Average Room Temp			
78	59	57	55
73	62	59.5	57
68	65	62	59

Preheat Coil Freeze Protection
The HW system is enabled if AC Unit low temperature detector trips.

Demand Control Ventilation
The minimum outside air setpoint is determined by the Siemens BAS. CO2 sensors located in high occupancy spaces detect the carbon dioxide concentration in the building. CO2 concentration shall be kept below 1,000 ppm differential relative to the ambient CO2 concentration outside by modulating the minimum outside air flow setpoint.

Unoccupied
The AC-Unit is disabled.

Night Heating:
The AC-Unit is enabled and forced into Morning Warmup. The supply air temperature setpoint is 85 deg. F. The heating water system is enabled. The VAV reheat control valves modulate as required and all VAV boxes are in heating mode. The VAV control dampers modulate to warm up the space to the space night heating setpoint of 64 deg. F. Night Heating mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 deg. F or less below the space heating setpoint (or 61 deg. F). Night heating mode ends when only two zones associated with the AC unit are below the space night heating setpoint (64 deg. F).

Night Cooling:
The AC-Unit is enabled. The VAV reheat control valves are closed (VAV boxes are in cooling mode). The VAV control dampers modulate to cool down the space to the space night cooling setpoint of 82 deg. F. Night Cooling mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 deg. F or more above the space cooling setpoint (or 85 deg. F). Night Cooling mode ends when only two zones associated with the AC unit are above the space night cooling setpoint (82 deg. F).

Unoccupied Override Switch
Selected room thermostat sensors shall have an override switch for each AC unit. Upon activation of the override switch during unoccupied hours, The AC-Unit is enabled and the VAV boxes and reheat coil control valves serving the respective quadrant shall modulate to maintain the day space cooling and heating setpoints. VAV boxes serving other floors shall remain in night mode unless an override switch or other switch in mode occurs.

Alarm & Safety Controls:
The following alarm points are monitored by the BAS:
1. Dirty Filter
2. VFD General Alarm
3. Supply Air Temperature Out of Range
4. Fan Status

Functional Performance Testing Procedure

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Equipment Tag:	AC-1, AC-2, AC-3, AC-4 & AC-5
Events	1: Unoccupied Mode/Night Heating/Night Cooling 2: Morning Warm-up/Cool-down 3: Occupied Mode 4: Resets/Overrides 5: Safeties/Alarms 6: Economizer Test

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS
Outside Air Temperature (F)	
Supply Air Temperatures (F)	
Return Air Temperatures (F)	
Supply Air Flow Rates (CFM)	
Return Air Flow Rates (CFM)	
Outside Air Flow Rates (CFM) (Flow station for AC-1 - AC-4)	5,000 - 10,000 cfm CO_2 control
CO2 Level (ppm)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
Supply Air Temp.		
Return Air Temp.		
CO2 Level		
Static Pressure	4 (in each quadrant on 1st flr.), 1 - kitchen	

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
Outside Air Dampers				
Return Air Damper				
Relief Air Damper				
CW control valve				
HHW control valve				

Status Check

Override control to each piece of equipment, note response.

Component	Responds?	Notes

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC-

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	1 a	**Unoccupied Mode:** With unit in occupied mode, override time clock to enable unoccupied mode	Outside air damper closed, return air damper open. Mechanical cooling disabled, supply and return fans OFF. CW and HHW control valves closed.	
☑	☐	1 b	**Night Heating:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below night htg setpt	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	Need to verify Petra goes into warm-up. Unit comes on.
☑	☐	1 c	**Night ~~Cooling~~:** Setup With unit in unoccupied mode, override OAT to be below ave space temp. and space temp. of 3 zones to be 3 F above night clg setpt	Outside air damper open, return air damper closed. Supply and return fans turn ON and ~~mechanical cooling is locked out.~~ VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	Ok. SAT setpt. 56. Triggered by space temp. of 85.
☑	☐	2 a	**Morning Warm-Up:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below day htg setpt and time clock to be 95 mins. before occupancy	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	0% OA warm SAT SAT setpt 120°F Fan -- 1.5 wg.
☑	☐	2 b	**Morning Cool-Down:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F above day clg setpt and time clock to be 95 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	3AM-5AM Cool down if space above setpt.; night setback at 85°F
☑	☐	3 a	**Occupied: 1st Stage Cooling** With unit in unoccupied mode, override OAT to be below ave space temp. and time clock to be 5 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling disabled. OA and RA dampers modulate to maintain SA Temp. to be at setpoint.	
☑	☐	3 b	**Occupied: 2nd Stage Cooling** With unit in occupied mode, override OAT to be above ave space temp.	Supply and return fans run continuously. Outside air damper closed to min. position, return air damper open. Mechanical cooling turns ON and modulate to maintain SA Temp. to be at setpoint.	

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC-

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	4 a	**Supply Air Temp. Reset:** With unit in occupied mode, override OAT and space temp. to simulate SAT reset strategy	The supply air temp. setpoint increases if OAT and/or Ave Space Temp. increase. Whereas SAT setpoint decreases if OAT and/or Ave Space Temp decrease.	Checked 61 SAT down to 56 when space temp. ↑ to 78°F
☑	☐	4 b	**Pre-heat Coil Operation:** With unit in occupied mode, override low temp. detector status to be low entering coil air temp.	Supply and return fans run continuously. HW system enabled. Outside air damper closed to min. position, return air damper open. HHW valve opens and modulate to maintain cooling coil entering air temp.to be above min. setpoint.	
☑	☐	4 c	**Demand Control Ventilation: CO2 Reset** With unit in occupied mode, override space CO2 level to be above setpt	Supply and return fans run continuously. Outside air damper opens from min. position and modulate to until space CO2 level is below setpoint.	
☑	☐	5 a	**Supply Fan Alarm:** With unit is running, override SF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 b	**Return Fan Alarm:** With unit is running, override RF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 c	**Compressor Alarm:** With unit in mechanical cooling mode, override compressor status to be OFF	Supply and return fans run continuously. Observe that the compressor stops and an alarm is generated at the BAS.	
☐	☐	5 e	**Smoke Detection Alarm:** With unit in occupied mode, activate supply air smoke detector	Upon smoke indication in the supply air duct, the SF and RF fan are truned OFF through a hardwire connection. An alarm is generated at the BAS.	Not tested due to hardwired to unit
☑	☐	5 f	**High Static Press Alarm:** With unit is running, override static pressure limit switch status to be high SA pressure	SF & RF ramp down to min. speed and an alarm is generated at the BAS.	
☑	☐	5 g	**Freezestat Alarm:** With unit in occupied mode, trip the freezestat switch	Minimum outside air damper closed, economizer outside damper closed, relief air damper closed, return air dampers open. Supply fans run continuously and CHW control valve closed.	
☑	☐	5 h	**Communication Loss w/ BAS** With unit in occupied mode, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. The current mode of operation is maintained.	

Functional Performance Test - Economizer

Equipment Tag: AH- /

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Remark / Other Observed System Responses
6a	**Simulate a cooling load and enable the economizer** *Overrides to simulate this mode:* Leave system in occupied mode. Simulate call for cooling thru DDC by setting temp. 5 F lower than currentspace set point temperature. If outdoor air temperature is lower than return air temperature, verify that economizer dampers are open for 100% outdoor air. Otherwise, use cold spray on outdoor air sensor to simulate condition. Then remove cold spray and verify that economizer dampers return to minimum air position. (else, use hand or hair dryer to warm the outdoor air sensor to simulate condition).	☐ Economizer damper modulates open to maximum position to provide 100% of design supply air quantity as outside air. ☐ Economizer damper returns to minimum outside air position. ☐ Return air damper modulates closed and is completely closed when economizer damper is 100% open. ☐ Economizer damper is 100% open before mechanical cooling is enabled. ☐ Relief is provided through barometric damper or powered relief (relief or return fan and exhaust damper). ☐ No heating provided. ☐ Mechanical cooling is only enabled if cooling space temperature setpoint is not met with economizer at 100% open. ☐ There are no signs of building overpressurization.	N/A
6b	**Simulate a cooling load and disable the economizer** *Overrides to simulate this mode:* Use BAS to override OA temperature to be >65 F	☐ Economizer damper closes to minimum position. ☐ Return air damper opens to normal operating position. ☐ Relief fan (if applicable) shuts off or barometric relief dampers close. If system uses a return fan, the exhaust damper is shut. ☐ Mechanical cooling remains enabled until cooling space temperature setpoint is met.	N/A

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC-2

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	1 a	**Unoccupied Mode:** With unit in occupied mode, override time clock to enable unoccupied mode	Outside air damper closed, return air damper open. Mechanical cooling disabled, supply and return fans OFF. CW and HHW control valves closed.	OA CFM 7 cfm SF OFF RF OFF
☑	☐	1 b	**Night Heating:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below night htg setpt	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	OA CFM shall be 0 in warmup mode.
☑	☐	1 c	**Night Cooling:** Setup With unit in unoccupied mode, override OAT to be below ave space temp. and space temp. of 3 zones to be 3 F above night clg setpt	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	unit overrides to be occupied.
☑	☐	2 a	**Morning Warm-Up:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below day htg setpt and time clock to be 95 mins. before occupancy	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	OA CFM MIN right at the time when building occupied.
☑	☐	2 b	**Morning Cool-Down:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F above day clg setpt and time clock to be 95 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	only enabled between 3:00am - 5:00 am mech cooling lockout
☑	☐	3 a	**Occupied: 1st Stage Cooling** With unit in unoccupied mode, override OAT to be below ave space temp. and time clock to be 5 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling disabled. OA and RA dampers modulate to maintain SA Temp. to be at setpoint.	
☑	☐	3 b	**Occupied: 2nd Stage Cooling** With unit in occupied mode, override OAT to be above ave space temp.	Supply and return fans run continuously. Outside air damper closed to min. position, return air damper open. Mechanical cooling turns ON and modulate to maintain SA Temp. to be at setpoint.	

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC-2

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	4 a	**Supply Air Temp. Reset:** With unit in occupied mode, override OAT and space temp. to simulate SAT reset strategy	The supply air temp. setpoint increases if OAT and/or Ave Space Temp. increase. Whereas SAT setpoint decreases if OAT and/or Ave Space Temp decrease.	
☑	☐	4 b	**Pre-heat Coil Operation:** With unit in occupied mode, override low temp. detector status to be low entering coil air temp.	Supply and return fans run continuously. HW system enabled. Outside air damper closed to min. position, return air damper open. HHW valve opens and modulate to maintain cooling coil entering air temp.to be above min. setpoint.	
☑	☐	4 c	**Demand Control Ventilation: CO2 Reset** With unit in occupied mode, override space CO2 level to be above setpt	Supply and return fans run continuously. Outside air damper opens from min. position and modulate to until space CO2 level is below setpoint.	If CO_2 level above 1000 ppm MIN will increase by 500CFM every 10 min
☑	☐	5 a	**Supply Fan Alarm:** With unit is running, override SF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 b	**Return Fan Alarm:** With unit is running, override RF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 c	**Compressor Alarm:** With unit in mechanical cooling mode, override compressor status to be OFF	Supply and return fans run continuously. Observe that the compressor stops and an alarm is generated at the BAS.	
☑	☐	5 e	**Smoke Detection Alarm:** With unit in occupied mode, activate supply air smoke detector	Upon smoke indication in the supply air duct, the SF and RF fan are truned OFF through a hardwire connection. An alarm is generated at the BAS.	Fire alarm trips the unit.
☑	☐	5 f	**High Static Press Alarm:** With unit is running, override static pressure limit switch status to be high SA pressure	SF & RF ramp down to min. speed and an alarm is generated at the BAS.	SF & RF off
☑	☐	5 g	**Freezestat Alarm:** With unit in occupied mode, trip the freezestat switch	Minimum outside air damper closed, economizer outside damper closed, relief air damper closed, return air dampers open. Supply fans run continuously and CHW control valve closed.	
☑	☐	5 h	**Communication Loss w/ BAS** With unit in occupied mode, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. The current mode of operation is maintained.	

Functional Performance Test - Economizer

Equipment Tag: AH-2

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Remark / Other Observed System Responses
6a	**Simulate a cooling load and enable the economizer** *Overrides to simulate this mode:* Leave system in occupied mode. Simulate call for cooling thru DDC by setting temp. 5 F lower than currentspace set point temperature. If outdoor air temperature is lower than return air temperature, verify that economizer dampers are open for 100% outdoor air. Otherwise, use cold spray on outdoor air sensor to simulate condition. Then remove cold spray and verify that economizer dampers return to minimum air position. (else, use hand or hair dryer to warm the outdoor air sensor to simulate condition).	☐ Economizer damper modulates open to maximum position to provide 100% of design supply air quantity as outside air. ☐ Economizer damper returns to minimum outside air position. ☐ Return air damper modulates closed and is completely closed when economizer damper is 100% open. ☐ Economizer damper is 100% open before mechanical cooling is enabled. ☐ Relief is provided through barometric damper or powered relief (relief or return fan and exhaust damper). ☐ No heating provided. ☐ Mechanical cooling is only enabled if cooling space temperature setpoint is not met with economizer at 100% open. ☐ There are no signs of building overpressurization.	N/A
6b	**Simulate a cooling load and disable the economizer** *Overrides to simulate this mode:* Use BAS to override OA temperature to be >65 F	☐ Economizer damper closes to minimum position. ☐ Return air damper opens to normal operating position. ☐ Relief fan (if applicable) shuts off or barometric relief dampers close. If system uses a return fan, the exhaust damper is shut. ☐ Mechanical cooling remains enabled until cooling space temperature setpoint is met.	N/A

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC- 3

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	1 a	**Unoccupied Mode:** With unit in occupied mode, override time clock to enable unoccupied mode	Outside air damper closed, return air damper open. Mechanical cooling disabled, supply and return fans OFF. CW and HHW control valves closed.	SF off, RF off, OA cfm=0
☑ see note	☐	1 b	**Night Heating:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below night htg setpt	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	OA = min., needs to be Ø
☑	☐	1 c	**Night Cooling:** With unit in unoccupied mode, override OAT to be below ave space temp. and space temp. of 3 zones to be 3 F above night clg setpt	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	100% OA
☐	X ☐	2 a	**Morning Warm-Up:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below day htg setpt and time clock to be 95 mins. before occupancy	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	Just comes to Warm-up when unit first turns on to occ. -Check- MW Startup Status -Not working 11/20
☑	☐	2 b	**Morning Cool-Down:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F above day clg setpt and time clock to be 95 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	Avg. Room Temp Above 74°F
☑	☐	3 a	**Occupied: 1st Stage Cooling** With unit in unoccupied mode, override OAT to be below ave space temp. and time clock to be 5 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling disabled. OA and RA dampers modulate to maintain SA Temp. to be at setpoint.	Note: can't see DX status from BAS
☑	☐	3 b	**Occupied: 2nd Stage Cooling** With unit in occupied mode, override OAT to be above ave space temp.	Supply and return fans run continuously. Outside air damper closed to min. position, return air damper open. Mechanical cooling turns ON and modulate to maintain SA Temp. to be at setpoint.	

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC- 3

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	4 a	**Supply Air Temp. Reset:** With unit in occupied mode, override OAT and space temp. to simulate SAT reset strategy	The supply air temp. setpoint increases if OAT and/or Ave Space Temp. increase. Whereas SAT setpoint decreases if OAT and/or Ave Space Temp decrease.	Checked control w/OAT
☑	☐	4 b	**Pre-heat Coil Operation:** With unit in occupied mode, override low temp. detector status to be low entering coil air temp.	Supply and return fans run continuously. HW system enabled. Outside air damper closed to min. position, return air damper open. HHW valve opens and modulate to maintain cooling coil entering air temp.to be above min. setpoint.	
☑	☐	4 c	**Demand Control Ventilation: CO2 Reset** With unit in occupied mode, override space CO2 level to be above setpt	Supply and return fans run continuously. Outside air damper opens from min. position and modulate to until space CO2 level is below setpoint.	OA cfm varies 5,000-10,000
☑	☐	5 a	**Supply Fan Alarm:** With unit is running, override SF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 b	**Return Fan Alarm:** With unit is running, override RF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 c	**Compressor Alarm:** With unit in mechanical cooling mode, override compressor status to be OFF	Supply and return fans run continuously. Observe that the compressor stops and an alarm is generated at the BAS.	
☐	☐	5 e	**Smoke Detection Alarm:** With unit in occupied mode, activate supply air smoke detector	Upon smoke indication in the supply air duct, the SF and RF fan are truned OFF through a hardwire connection. An alarm is generated at the BAS.	Not tested due to hardwired to unit.
☑	☐	5 f	**High Static Press Alarm:** With unit is running, override static pressure limit switch status to be high SA pressure	SF & RF ramp down to min. speed and an alarm is generated at the BAS.	SF & RF off
☑	☐	5 g	**Freezestat Alarm:** With unit in occupied mode, trip the freezestat switch	Minimum outside air damper closed, economizer outside damper closed, relief air damper closed, return air dampers open. Supply fans run continuously and CHW control valve closed.	
☑	☐	5 h	**Communication Loss w/ BAS** With unit in occupied mode, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. The current mode of operation is maintained.	

Functional Performance Test - Economizer

Equipment Tag: AH- 5

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Remark / Other Observed System Responses
6a	**Simulate a cooling load and enable the economizer** *Overrides to simulate this mode:* Leave system in occupied mode. Simulate call for cooling thru DDC by setting temp. 5 F lower than currentspace set point temperature. If outdoor air temperature is lower than return air temperature, verify that economizer dampers are open for 100% outdoor air. Otherwise, use cold spray on outdoor air sensor to simulate condition. Then remove cold spray and verify that economizer dampers return to minimum air position. (else, use hand or hair dryer to warm the outdoor air sensor to simulate condition).	☐ Economizer damper modulates open to maximum position to provide 100% of design supply air quantity as outside air. ☐ Economizer damper returns to minimum outside air position. ☐ Return air damper modulates closed and is completely closed when economizer damper is 100% open. ☐ Economizer damper is 100% open before mechanical cooling is enabled. ☐ Relief is provided through barometric damper or powered relief (relief or return fan and exhaust damper). ☐ No heating provided. ☐ Mechanical cooling is only enabled if cooling space temperature setpoint is not met with economizer at 100% open. ☐ There are no signs of building overpressurization.	N/A
6b	**Simulate a cooling load and disable the economizer** *Overrides to simulate this mode:* Use BAS to override OA temperature to be >65 F	☐ Economizer damper closes to minimum position. ☐ Return air damper opens to normal operating position. ☐ Relief fan (if applicable) shuts off or barometric relief dampers close. If system uses a return fan, the exhaust damper is shut. ☐ Mechanical cooling remains enabled until cooling space temperature setpoint is met.	N/A

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC- 4

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	1 a	**Unoccupied Mode:** With unit in occupied mode, override time clock to enable unoccupied mode	Outside air damper closed, return air damper open. Mechanical cooling disabled, supply and return fans OFF. CW and HHW control valves closed.	SF, RF off, OA cfm.
☑ need to change OA	☐	1 b	**Night Heating:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below night htg setpt	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	60°F trigger SF, RF on OA at min. 5000 cfm, not 0 cfm
☑	☐	1 c	**Night Cooling:** (Mech.) With unit in unoccupied mode, override OAT to be below ave space temp. and space temp. of 3 zones to be 3 F above night clg setpt	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	~~[illegible]~~ Setup temp. 85°F space
☐	☐	2 a	**Morning Warm-Up:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below day htg setpt and time clock to be 95 mins. before occupancy	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	Not tested.
☑	☐	2 b	**Morning Cool-Down:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F above day clg setpt and time clock to be 95 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	3AM-5AM & OA 10°F below space temp.
☑	☐	3 a	**Occupied: 1st Stage Cooling** With unit in unoccupied mode, override OAT to be below ave space temp. and time clock to be 5 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling disabled. OA and RA dampers modulate to maintain SA Temp. to be at setpoint.	
☑	☐	3 b	**Occupied: 2nd Stage Cooling** With unit in occupied mode, override OAT to be above ave space temp.	Supply and return fans run continuously. Outside air damper closed to min. position, return air damper open. Mechanical cooling turns ON and modulate to maintain SA Temp. to be at setpoint.	

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC- 4

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	4 a	**Supply Air Temp. Reset:** With unit in occupied mode, override OAT and space temp. to simulate SAT reset strategy	The supply air temp. setpoint increases if OAT and/or Ave Space Temp. increase. Whereas SAT setpoint decreases if OAT and/or Ave Space Temp decrease.	Checked w/ space temp.
☑	☐	4 b	**Pre-heat Coil Operation:** With unit in occupied mode, override low temp. detector status to be low entering coil air temp.	Supply and return fans run continuously. HW system enabled. Outside air damper closed to min. position, return air damper open. HHW valve opens and modulate to maintain cooling coil entering air temp.to be above min. setpoint.	
☑	☐	4 c	**Demand Control Ventilation: CO2 Reset** With unit in occupied mode, override space CO2 level to be above setpt	Supply and return fans run continuously. Outside air damper opens from min. position and modulate to until space CO2 level is below setpoint.	increases in 500 cfm increments 500ppm - 1000ppm range
☑	☐	5 a	**Supply Fan Alarm:** With unit is running, override SF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 b	**Return Fan Alarm:** With unit is running, override RF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 c	**Compressor Alarm:** With unit in mechanical cooling mode, override compressor status to be OFF	Supply and return fans run continuously. Observe that the compressor stops and an alarm is generated at the BAS.	
☐	☐	5 e	**Smoke Detection Alarm:** With unit in occupied mode, activate supply air smoke detector	Upon smoke indication in the supply air duct, the SF and RF fan are truned OFF through a hardwire connection. An alarm is generated at the BAS.	Not tested due to hardwire to unit.
☑	☐	5 f	**High Static Press Alarm:** With unit is running, override static pressure limit switch status to be high SA pressure	SF & RF ramp down to min. speed and an alarm is generated at the BAS.	SF & RF OFF
☑	☐	5 g	**Freezestat Alarm:** With unit in occupied mode, trip the freezestat switch	Minimum outside air damper closed, economizer outside damper closed, relief air damper closed, return air dampers open. Supply fans run continuously and CHW control valve closed.	
☑	☐	5 h	**Communication Loss w/ BAS** With unit in occupied mode, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. The current mode of operation is maintained.	

Functional Performance Test - Economizer

Equipment Tag: AH- 4

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Remark / Other Observed System Responses
6a	**Simulate a cooling load and enable the economizer** *Overrides to simulate this mode:* Leave system in occupied mode. Simulate call for cooling thru DDC by setting temp. 5 F lower than currentspace set point temperature. If outdoor air temperature is lower than return air temperature, verify that economizer dampers are open for 100% outdoor air. Otherwise, use cold spray on outdoor air sensor to simulate condition. Then remove cold spray and verify that economizer dampers return to minimum air position. (else, use hand or hair dryer to warm the outdoor air sensor to simulate condition).	☐ Economizer damper modulates open to maximum position to provide 100% of design supply air quantity as outside air. ☐ Economizer damper returns to minimum outside air position. ☐ Return air damper modulates closed and is completely closed when economizer damper is 100% open. ☐ Economizer damper is 100% open before mechanical cooling is enabled. ☐ Relief is provided through barometric damper or powered relief (relief or return fan and exhaust damper). ☐ No heating provided. ☐ Mechanical cooling is only enabled if cooling space temperature setpoint is not met with economizer at 100% open. ☐ There are no signs of building overpressurization.	N/A
6b	**Simulate a cooling load and disable the economizer** *Overrides to simulate this mode:* Use BAS to override OA temperature to be >65 F	☐ Economizer damper closes to minimum position. ☐ Return air damper opens to normal operating position. ☐ Relief fan (if applicable) shuts off or barometric relief dampers close. If system uses a return fan, the exhaust damper is shut. ☐ Mechanical cooling remains enabled until cooling space temperature setpoint is met.	N/A

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC- 5

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	1 a	**Unoccupied Mode:** With unit in occupied mode, override time clock to enable unoccupied mode	Outside air damper closed, return air damper open. Mechanical cooling disabled, supply and return fans OFF. CW and HHW control valves closed.	Fans off - need to verify valves at unit
☑	☐	1 b	**Night Heating:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below night htg setpt	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	OA CFM shall be 0 in warm up mode.
☑ ★	☐	1 c	**Night Cooling:** With unit in unoccupied mode, override OAT to be below ave space temp. and space temp. of 3 zones to be 3 F above night clg setpt	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	OAT=MAT check mech. cooling for night setup (>85 space temp.)
☐	☒ ☐	2 a	**Morning Warm-Up:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below day htg setpt and time clock to be 95 mins. before occupancy	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	Retest - didn't work 11/20
☑	☐	2 b	**Morning Cool-Down:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F above day clg setpt and time clock to be 95 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	
☑	☐	3 a	**Occupied: 1st Stage Cooling** With unit in unoccupied mode, override OAT to be below ave space temp. and time clock to be 5 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling disabled. OA and RA dampers modulate to maintain SA Temp. to be at setpoint.	
☑	☐	3 b	**Occupied: 2nd Stage Cooling** With unit in occupied mode, override OAT to be above ave space temp.	Supply and return fans run continuously. Outside air damper closed to min. position, return air damper open. Mechanical cooling turns ON and modulate to maintain SA Temp. to be at setpoint.	

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC- 5

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☑	☐	4 a	**Supply Air Temp. Reset:** With unit in occupied mode, override OAT and space temp. to simulate SAT reset strategy	The supply air temp. setpoint increases if OAT and/or Ave Space Temp. increase. Whereas SAT setpoint decreases if OAT and/or Ave Space Temp decrease.	Checked w/ room temp.
☑	☐	4 b	**Pre-heat Coil Operation:** With unit in occupied mode, override low temp. detector status to be low entering coil air temp.	Supply and return fans run continuously. HW system enabled. Outside air damper closed to min. position, return air damper open. HHW valve opens and modulate to maintain cooling coil entering air temp.to be above min. setpoint.	
N/A ☐	☐	4 c	**Demand Control Ventilation: CO2 Reset** With unit in occupied mode, override space CO2 level to be above setpt	Supply and return fans run continuously. Outside air damper opens from min. position and modulate to until space CO2 level is below setpoint.	N/A
☑	☐	5 a	**Supply Fan Alarm:** With unit is running, override SF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 b	**Return Fan Alarm:** With unit is running, override RF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☑	☐	5 c	**Compressor Alarm:** With unit in mechanical cooling mode, override compressor status to be OFF	Supply and return fans run continuously. Observe that the compressor stops and an alarm is generated at the BAS.	
☐	☐	5 e	**Smoke Detection Alarm:** With unit in occupied mode, activate supply air smoke detector	Upon smoke indication in the supply air duct, the SF and RF fan are truned OFF through a hardwire connection. An alarm is generated at the BAS.	Not tested due to hardwire to unit.
☑	☐	5 f	**High Static Press Alarm:** With unit is running, override static pressure limit switch status to be high SA pressure	SF & RF ramp down to min. speed and an alarm is generated at the BAS.	SF & RF off
☑	☐	5 g	**Freezestat Alarm:** With unit in occupied mode, trip the freezestat switch	Minimum outside air damper closed, economizer outside damper closed, relief air damper closed, return air dampers open. Supply fans run continuously and CHW control valve closed.	
☑	☐	5 h	**Communication Loss w/ BAS** With unit in occupied mode, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. The current mode of operation is maintained.	

Functional Performance Test - Economizer

Equipment Tag: AH-5

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Remark / Other Observed System Responses
6a	**Simulate a cooling load and enable the economizer** *Overrides to simulate this mode:* Leave system in occupied mode. Simulate call for cooling thru DDC by setting temp. 5 F lower than currentspace set point temperature. If outdoor air temperature is lower than return air temperature, verify that economizer dampers are open for 100% outdoor air. Otherwise, use cold spray on outdoor air sensor to simulate condition. Then remove cold spray and verify that economizer dampers return to minimum air position. (else, use hand or hair dryer to warm the outdoor air sensor to simulate condition).	☐ Economizer damper modulates open to maximum position to provide 100% of design supply air quantity as outside air. ☐ Economizer damper returns to minimum outside air position. ☐ Return air damper modulates closed and is completely closed when economizer damper is 100% open. ☐ Economizer damper is 100% open before mechanical cooling is enabled. ☐ Relief is provided through barometric damper or powered relief (relief or return fan and exhaust damper). ☐ No heating provided. ☐ Mechanical cooling is only enabled if cooling space temperature setpoint is not met with economizer at 100% open. ☐ There are no signs of building overpressurization.	N/A
6b	**Simulate a cooling load and disable the economizer** *Overrides to simulate this mode:* Use BAS to override OA temperature to be >65 F	☐ Economizer damper closes to minimum position. ☐ Return air damper opens to normal operating position. ☐ Relief fan (if applicable) shuts off or barometric relief dampers close. If system uses a return fan, the exhaust damper is shut. ☐ Mechanical cooling remains enabled until cooling space temperature setpoint is met.	N/A

Functional Performance Testing Procedure

System:	Makeup Air Unit
Title:	Makeup Air Unit for Kitchen Exhaust
Equipment Tag:	MUA-1

Participants:	**Name**	**Organization**
Date: 11/28/08	Derek	AEC
	Allen Ho	AEC
	Rich	BPM

Comments:

Sequence:

General:
The MUA-Unit is located on the 3rd floor roof. Unit contains a 30% pre-filter, 2-stage gas furnace, and stainless steel heat exchanger. Unit serves compensating hood for 1st floor kitchen and interlocked with Gaylord (or equal) Control Panel & hood exhaust fan (EF-7).

Start/Stop
The supply fan in the make up air unit is enabled/disabled by the BAS.

Smoke Detector
Upon detection of smoke in the discharge of MUA-unit, the MUA supply fan is shut down upon alarm. This function is not provided by the BAS.

Heating Setpoint
The gas-fired furnace shall stage to maintain a supply air temperature setpoint of 65 F.

Alarms
The following alarm points are monitored by the BAS:
1. Dirty Filter
2. Fan Status

Emergency Power Mode
Upon loss of Normal Power, MUA unit shuts down.

Events
1: Startup/Shutdown
2: Unoccupied Mode
3: Occupied Mode
4: Safeties/Alarms

Operation Schedule

Record programmed schedule.

	Schedule	**Notes**
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	**Value programmed in BAS**
Supply Air Temp (F)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	**Actual Location**	**Notes**
SA Temp		

Functional Performance Test

System:	Makeup Air Unit
Title:	Makeup Air Unit for Kitchen Exhaust
Tag:	MUA-1

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	1	**Startup/Shutdown** Verify that the unit can be operated in each of the three modes listed below, 1. Automatically based on time schedule in BAS 2. Manually using local "ON/OFF" switch 3. Override ON/OFF thru BAS.	System turns ON and OFF in accordance with the interlock time sequence with Kitchen EF. Observe that unit truns ON and "Local ON" is shown on BAS screen. After the "ON/OFF" is pressed again, unit turns OFF and "Local OFF" alarm is generated at BAS. It responses to override from BAS, and reset to original operation mode after the override is removed.	✓ Override thru BAS shall not be available
☑	☐	2	**Unoccupied Mode** With unit is running, override MAU status to be OFF.	Observe that MAU turns off and OA damper close.	
☑	☐	3 a	**Occupied Mode - Heating** With unit in operation, override supply air temp to be 5 deg. F below htg setpt space temp	Observe that the fan runs continuously. The gas burner turns on. MUA controls modulate the burner firing rate to maintain supply air temp at setpoint.	
☑	☐	3 b	**Occupied Mode - No heating** With unit in heating mode, override supply air temp to be 5 deg. F below htg setpt Space temp	Observe that the gas burner turns OFF and the fan runs continuously.	
☐	☐	4 a	**Fan Alarm** With unit is running, override fan status to be OFF	The gas burner shuts off. Fan stops and an alarm is generated at BAS.	N/A
☐	☐	4 b	**Smoke Detection Alarm** With unit is running, activate the supply duct smoke detector.	Upon smoke indication in the supply air duct, supply fan shall be stopped through a hardwire connection. Unit status will be changed to unoccupied mode.	N/A
☐	☐	4 c	**Supply Air Temp Alarm** With unit in heating mode, override supply air temperature to be exceeded active setpoint by +/- 10 deg. F	The fan runs continuously and the gas burner turns off. An alarm is generated at BAS.	N/A

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-7

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy** *Overrides to simulate this mode*: Stop FAN by changing the Occupancy Schedule	☐ Fan stops - status OFF ☐ Backdraft damper closes	N/A
2	**General Control - Interlock with equipment /service** *Overrides to simulate this mode*: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☑ Changing Occupancy has no effect on the fan ☑ Fan comes on when equipment on /service enable ☑ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat** *Overrides to simulate this mode*: Turn thermostat higher than room temp, then lower than room temp.	☐ Changing Occupancy has no effect on the fan ☐ Fan comes on when thermostat calls for it. ☐ Fan stops when set higher than room temperature ☐ Fan starts when set lower than room temperature	N/A
4	**General Control - No control** *Overrides to simulate this mode:* Make this observation when testing exhaust fans in unoccupied mode	☐ Changing Occupancy has no effect on the fan, fan always on ☐ Fan always on ☐ Backdraft damper is open & does not impede air flow	N/A
5	**Fan control by local, dedicated toggle switch** *Overrides to simulate this mode*: Toggle ON - OFF	☐ Switch in 'ON' position - Fan 'ON' ☐ Switch in 'OFF' position - Fan 'OFF' ☐ System turns OFF when manual override time period expires	N/A
6	**Interlock Sequence** *Overrides to simulate this mode*: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☑ Fan starts when call on by interlock sequence ☑ Fan stops when called off by interlock sequence ☑ Sequence verified ☐ Power actuated/gravity damper operation verified	Interlock w/ MUA-1

Notes:

10.0 Field Commissioning Documentation

This section includes blank functional performance tests (FPTs) forms developed for commissioning of HVAC, DHW, and lighting control systems. FPTs provides functional performance testing procedure, ways to simulate various operation conditions, expected observations and results, and the remark column to put down additional observations and comments.

Final version of the Sequence of Operation of the corresponding system to be commissioning is also included into introduction section of the FPTs forms as a hands-on reference for testing personnel.

Functional Performance Testing Procedure

System:	Cendenser Water System	
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps	
Equipment Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6	
Participants:	**Name**	**Organization**
Date:		
Comments:		

Sequence:

Cooling Tower and Tower Loop Pumps - TOWER LOOP
Two (2) open cooling towers provide condenser water pumped through the tower loop side of the plate heat exchanger by condenser water pumps with VFDs. The cooling towers are complete with vibration switches and VFDs. Additional condenser water pumps with VFDs circulate the building loop water through the plate heat exchanger and the building systems, including the rooftop AC units, CRACs, and water-source heat pumps (PCUs).
This system will have a low load condition during off hours (when the AC units are off) and during the winter (when the AC units satisfy their cooling requirements with economizer operation only). Low load condenser water pumps, on both the tower loop and building loop, provide low flow when required. Since this system serves CRAC units and water-source heat pumps (PCUs) that operate 24/7/365, this system is always enabled and operation (when normal power is available).

Staging Control
There are 2 stages of cooling in the sequence. Stage 1 Cooling is for low CW loads. Stage 1 Cooling uses only the small CW pump (CWP-3) and the lead cooling tower. Stage 2 Cooling is for moderate to maximum CW loads. Stage 2 Cooling uses both large CW pumps (CWP-1 and CWP-2) and both cooling towers. The cooling tower system is staged to maintain a condenser water supply temperature to setpoint (variable - 65 to 80 deg. F). Please refer to the attached "Cooling Tower Load Sequencing" for additional details on how the equipment is sequenced to maintain the supply temperature to setpoint.
When Stage 1 is active and Stage 1 is at maximum cooling and the CW supply temperature is greater than setpoint for 5 minutes, Stage 2 cooling is started.
When Stage 2 is active and Stage 2 is at minimum cooling and the CW supply temperature is less than setpoint for 15 minutes, Stage 1 cooling is started.

Condenser Water Supply Temperature Setpoint Optimization
Cooling Towers are limited in their cooling capacity by the outdoor air wetbulb temperature. The condenser water supply temperature setpoint is optimized to provide the coldest possible CW (low limit of 65 deg. F) without wasting energy due to OA wetbulb limitations. When the outdoor air wetbulb temperature is lower than 55 deg. F, the condenser water supply temperature setpoint is 65 deg. F. As the outdoor air wetbulb temperature rises above 55 deg. F, the condenser water supply temperature setpoint is reset to be the outdoor air wetbulb temperature plus 10 deg. F (high limit of 80 deg. F).

Lead/Lag/Standby Rotation: Lead/Lag rotation of the cooling towers occurs monthly.

Condenser Water Pumps - BUILDING LOOP
(2) 50% duty variable speed Condenser Water Pumps (CWP-4, 5) and (1) low-load variable speed constant water pump (CWP-6) are arranged in parallel serving a common header. The pumps are staged and modulate in speed to maintain the building CW differential pressure to setpoint.

Pump Failure
If a CWP faiis to start when commanded on by the BAS, an aiarm is generated and the next pump in the sequence is started.

Functional Performance Testing Procedure

System:	Cendenser Water System
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps
Equipment Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6

Building Loop Differential Pressure Control
CWP-6 is always the lead pump (used for low loads) and CWP-4 and CWP-5 alternate as Lag1 and Lag2 pumps. The building loop condenser water pump VFDs operate to maintain a differential pressure to setpoint (initially 5 psig). CWP-6 is started and modulates in speed to maintain differential pressure to setpoint.
When CWP-6 is at 100% speed for 2 minutes, CWP-6 is stopped and the Lag1 CWP is started. The Lag1 pump modulates in speed from minimum to maximum.
When the Lag1 pump is at 100% speed for 2 minutes, the Lag2 pump is started. Both the Lag1 and Lag2 pumps modulate at the same speed from minimum to maximum.
When the Lag1 and Lag2 pumps are less than 62% speed for 10 minutes, the Lag2 pump is stopped.
When the Lag1 pump is less than 62% speed for 10 minutes. the Lag1 pump is stopped and CWP-6 is started.

Alarms
The following alarm points are monitored by the BAS:
1. VFD General Alarm
2. Cooling Tower Isolation Valve end switches
3. Condenser Water high /low limit
4. Pump status

Emergency Power Mode
Upon loss of Normal Power, CT-2 is disabled and CT-1 is allowed to operate.
The control valves for CT-1 open and the control valves for CT-2 close. Cooling is switched to Stage 1.
CWP-1, 2 shut down and CWP-3 continues to operate.
CWP-4, 5 shut down and CWP-6 continues to operate.

Events
1: Startup/Shutdown
2: Occupied Mode
3: Temperature Reset
4: Safeties/Alarms

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS
CW supply Temp (F)	
CW return Temp (F)	
Diff. Pressure Sensor (Psi)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
CWS Temp		
CWR Temp		
DP Sensor		

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
CT-1 Iso Valve				
CT-2 Iso Valve				

Functional Performance Test

System:	Cendenser Water System
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps
Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	1	**Startup/Shutdown** Verify that the system can be operated in each of the three modes listed below, 1. Based on the time schedule 2. Manually override from BAS	System turns ON and OFF in accordance with time clock. It responses to override from BAS, and reset to original operation mode after the override is removed.	
☐	☐	2 a	**Occupied Mode: Low Flow Condition** With CW system in unoccupied mode, override supply CW temp. to be within deadband and time clock be 5 minutes before occupancy	Lead SCWP starts and runs at Min. speed. Lead CT is enabled, Iso valve opens and fan OFF. Lag CT is disabled, Iso valve is closed and fan OFF. Lead PCWP starts and runs at 100% speed. All lag CWPs are OFF.	
☐	☐	2 b	**Tower Loop Stage 1 ON** With CW system in occupied mode, override supply CW temp. to be above setpt	Lead SCWP and lead PCWP run continuously. All lag CWPs are OFF. Lag CT is disabled. Lead CT fan modulates between Min. & Max. to maintain supply CW temp. at setpt.	
☐	☐	2 c	**Tower Loop Stage 2 ON** With Tower Loop at Stage 1 maximum, override supply CW temp. to be above setpt and wait for 10 minutes	Lead SCWP runs continuously. Lag SCWPs are OFF. Lead PCWP shuts down and lag 1 PCWP turns on. Lag CT is enabled and Iso valve opens. Lead & lag CT fans and Lag 1 & 2 PCWPs modulates between Min. & Max. to maintain supply CW temp. at setpt.	
☐	☐	2 d	**Tower Loop Stage 2 OFF** With Tower Loop at Stage 2 minimum, override supply CW temp. to be below setpt and wait for 10 minutes	Lead SCWP runs continuously. Lag SCWPs are OFF. Lag 1 PCWP shuts down and lead PCWP turns on. Lag CT fan OFF, Iso valve closes and is disabled. Lead CT fan modulates between Min. & Max. to maintain supply CW temp. at setpt.	

Functional Performance Test

System:	Cendenser Water System
Title:	Two cooling towers, three primary CW pumps, one plate type heat exchanger, and three secondary CW pumps
Tag:	CT-1 & 2, CWP-1 & 2, CWP-3, HX-1, CWP-4 & 5, CWP-6

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	2 e	**Building Loop 1st Stage ON** With CW system in occupied mode, override CW diff.pressure to be below setpt	Lead PCWP and lead CT fan run continuously. Lag PCWPs are OFF. Lag CT is disabled. Lead SCWP shuts down and lag 1 SCWP turns on. Lag 1 SCWP modulates to maintain CW diff. pressure to be at setpt.	
☐	☐	2 f	**Building Loop 2nd Stage ON** With Lag 1 SCWP is running, override CW diff.pressure to be below setpt	Lead PCWP and lead CT fan run continuously. Lag PCWPs are OFF. Lag CT is disabled. Lag 1 SCWP ramps to 100% speed. Lag 2 SCWP starts after 5 mins. Lag 1 & 2 SCWPs run in unison and modulate to maintain CW diff. pressure to be at setpt.	
☐	☐	2 g	**Building Loop 2nd Stage OFF** With Lag 1 & 2 SCWPs are running, override CW diff.pressure to be above setpt and wait for 15 mins	Lead PCWP and lead CT fan run continuously. Lag PCWPs are OFF. Lag CT is disabled. Lag SCWPs ramp down and Lag 2 SCWP shuts down after 10 mins. Lag 1 SCWP ramp up and modulate to maintain CW diff. pressure to be at setpt.	
☐	☐	3	**Supply CW Temp Reset** With CW system in occupied mode, override OA wetbulb temp to be 5 deg. F above the actual value	CW supply temp setpt automatically adjusted to OA wetbulb temp plus 10 deg. F or the max. value of 80 deg. F. CW system stages ON to increase the rate of heat rejection.	
☐	☐	4 a	**Cooling Tower Alarm:** With lead CT is ON, override CT status to be OFF	Lead CT shuts down and lag CT turns ON. An alarm is generated at the BAS.	
☐	☐	4 b	**Primary CW Pump Alarm (CWP-1 to 3)** With lead PCWP is running, override CW pump status to be OFF	Lead CW pump shuts down and lag CW pump turns ON. An alarm is generated at the BAS.	
☐	☐	4 c	**Secondary CW Pump Alarm (CWP-4 to 6)** With lead SCWP is running, override CW pump status to be OFF	Lead CW pump shuts down and lag CW pump turns ON. An alarm is generated at the BAS.	
☐	☐	4 d	**CW System Alarm:** With CW system in operation, override system status to be unoccupied	CRAC units switches to 'Bypass' mode and Drycoolers are enabled. CW system shut down and an alarm is generated at the BAS.	

Cooling Tower (Tower Loop) Load Sequencing of Caltrans - Marysville

Tower CW Load	Stage 1			Stage 2			
	Min	**Mid**	**Max**	**Min**	**33%**	**66%**	**Max**
Lead Tower Iso Valves	Open	Open	Open	Open	Open	Open	Open
Lead Tower Fans	Off	On – 25%	On – 100%	On – 25%	On – 50%	On – 50%	On – 100%
Lag Tower Iso Valves	Closed	Closed	Closed	Open	Open	Open	Open
Lag Tower Fans	Off	Off	Off	On – 25%	On – 50%	On – 50%	On – 100%
Lead Tower CWP (Always CWP-3)	On – 100%	On – 100%	On – 100%	Off	Off	Off	Off
Lag1 Tower CWP (Primary Loop)	Off	Off	Off	On – 50%	On – 50%	On – 100%	On – 100%
Lag2 Tower CWP (Primary Loop)	Off	Off	Off	On – 50%	On – 50%	On – 100%	On – 100%

Functional Performance Testing Procedure

System:	Heating Hot Water System	
Title:	Three Boilers w/ circulating pumps and two HW pumps	
Equipment Tag:	B-1, B-2, B-3, HWP-1 & HWP-2	
Participants:	**Name**	**Organization**
Date:		
Comments:		

Sequence:

General:
This system is controlled by the Siemens BAS. The primary/secondary hot water system consists of three (3) boilers with integral primary pumps-including one 50% backup boiler-and two hot water secondary pumps with VFDs. The hot water system circulates secondary hot water generated by the boilers to AC Unit preheat coils and VAV hot water reheat coils.
Two (2) Secondary Hot Water Pumps (SHWP) are arranged in parallel serving a common header. Each pump is provided with a variable frequency drive (VFD). Hot water from the secondary hot water loop is circulated to the AC units on the roofs and VAV reheat coils on all floors.

Hot Water Setpoint: The hot water system shall maintain 180 deg.F supply water in the primary loop. No hot water temperature reset is provided.

Heating Hot Water System (Primary Loop)

Occupied Start/Stop (normal building hours)
The hot water system is enabled by the BAS when a request for heating is generated by four or more VAV hot water reheat coils or one or more AC unit preheat coils. The hot water system is disabled by the BAS when a request for heating is generated by two or less VAV hot water reheat coils and no AC unit preheat coils. When the hot water system is enabled, the factory mounted local controller on the lead boiler is commanded on. The local boiler controller provides local boiler control. When the primary HW supply temperature is less than 160 deg. F for 10 minutes, the lag boiler is enabled by the BAS. When the primary HW supply temperature is greater than 175 deg. F and the primary HW differential temperature is less than 10 deg. F for 20 minutes, the lag boiler is disabled by the BAS.

Lead/Lag Rotation: Lead/Lag rotation of the Boilers occurs monthly.

Unoccupied Night Heating, Warm-Up, Override Modes
Upon call for Night Heating, Morning Warm-Up, or activation of AC unit Override during unoccupied hours, the hot water system switches to normal building hour operation for the duration of the mode. With no call for Night Heating, Morning Warm-Up, nor activation of AC unit Override during unoccupied hours, the hot water system is disabled.

Boiler Failure: If the lead Boiler fails to start, an alarm is generated by the BAS. The lead boiler is locked out and the lag Boiler becomes the lead Boiler. The backup boiler becomes the lag boiler.

Secondary Hot Water Pumps

Start/Stop (normal building hours)
The lead hot water pump (HWP-1 or HWP-2) starts at minimum speed after the hot water system is enabled. The lead hot water pump VFD modulates to maintain the differential pressure setpoint in the secondary hot water loop. When differential pressure setpoint falls below setpoint and the lead pump has been at 100% speed for 10 minutes, the lag hot water pump starts. When differential pressure setpoint is at setpoint and both pumps has been at less than 60% speed for 20 minutes, the lag hot water pump stops.

Functional Performance Testing Procedure

System:	Heating Hot Water System
Title:	Three Boilers w/ circulating pumps and two HW pumps
Equipment Tag:	B-1, B-2, B-3, HWP-1 & HWP-2
	Speed Control: Pump speed is modulated by the BAS to maintain a differential pressure of 5 psi (adj.) in the secondary hot water loop. Lead/Lag Rotation: Lead/Lag rotation of SHWP occurs monthly. Pump Failure: If a SHWP fails to start when commanded on by the BAS, an alarm is generated and the lag pump is started.
	Alarms The following alarm points are monitored by the BAS: 1. Boiler controller general alarm 2. Pump status **Emergency Power Mode** Upon loss of Normal Power, The BAS disables all boilers and pumps.
Events	1: Startup/Shutdown 2: Occupied Mode 3: Unoccupied Mode 4: Safeties/Alarms

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes

Status Check

Override control to each piece of equipment, note response.

Component	Responds?	Notes

Functional Performance Test

System:	Heating Hot Water System
Title:	Three Boilers w/ circulating pumps and two HW pumps
Tag:	B-1, B-2, B-3, HWP-1 & HWP-2

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	1	**Startup/Shutdown** Verify that the system can be operated in each of the three modes listed below, 1. Based on number of heat requests 2. Lockout due to high OA temperature 3. Manually override from BAS	System turns ON and OFF in accordance with the incoming heat requests. System will be lockout if the OAT in above 65 F. It responses to override from BAS, and reset to original operation mode after the override is removed.	
☐	☐	2 a	**Occupied Mode: No Heating** With HHW system in unoccupied mode, override supply HHW temp. to be within deadband and heat requests to be above setpoint	Lead HW pump ON. Lead boiler circulating pump turns ON and the lead boiler is enabled.	
☐	☐	2 b	**Occupied Mode: Lag Pump Stage ON** With HHW system in occupied mode, override building HHW diff. pressure to be below setpt	Lead HW pump ramps up to full speed. After 10 minutes, lag HW pump turns ON. Lead and lag HW pumps run in unison sharing the same load.	
☐	☐	2 c	**Occupied Mode: 1st Stage Heating** With HHW system in occupied mode, override supply HHW temp. to be below setpt	Lead HW pump runs continuously. Lead boiler turns ON and modulate to maintain boiler loop HHW temp. to be at setpoint.	
☐	☐	2 d	**Occupied Mode: 2nd Stage ON** With lead boiler is ON, override supply HHW temp. to be below 160 deg. F and wait for 10 minutes	Lead HW pump runs continuously. Lead boiler is ON. Lag boiler circulating pump turns ON. Lag boiler is enabled and then turns ON. Lead and lag boilers run in unison sharing the same load.	
☐	☐	2 e	**Occupied Mode: 2nd Stage OFF** With lead and lag boiler is ON, override supply HHW temp. to be above 175 deg. F, HHW diff. temp to be less than 10 deg. F and wait for 20 minutes	Lead HW pump runs continuously. Lead boiler is ON. Lag boiler turns OFF and is disabled. Lag boiler circulating pump turns OFF after 15 mins.	

Functional Performance Test

System:	Heating Hot Water System
Title:	Three Boilers w/ circulating pumps and two HW pumps
Tag:	B-1, B-2, B-3, HWP-1 & HWP-2

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	3 a	**Unoccupied Night Heating Mode** With HHW system and building are in unoccupied mode, override building status to be night heating mode	HHW system starts and operates in the Occupied Mode.	
☐	☐	3 b	**Unoccupied Morning Warm-up Mode** With HHW system and building are in unoccupied mode, override space temp to be below occupied htg setpt and time clock to be 30 minutes before occupancy	Morning warm-up sequence is enabled. HHW system starts and operates in the Occupied Mode.	
☐	☐	3 c	**Freeze Protection Mode** With HHW system and building are in unoccupied mode, override OA temp to be below 45 deg. F	Heating coil control valves of AHUs open to minimum position. HHW system starts and operates in the Occupied Mode.	
☐	☐	4 a	**Boiler Alarm:** With lead boiler is ON, override boiler status to be OFF	Lead boiler shuts down and lag boiler stages ON. An alarm is generated at the BAS.	
☐	☐	4 b	**HW Pump Alarm:** With lead HW pump is running, override HW pump status to be OFF	Lead HW pump shuts down and lag HW pump stages ON. An alarm is generated at the BAS.	
☐	☐	4 c	**High HHW Temp. Alarm:** With HHW system in occupied mode, override supply HHW temp. to be 20 deg. F above setpt and wait for 15 mins.	Boiler stages OFF and an alarm is generated at the BAS.	
☐	☐	4 d	**Low HHW Temp. Alarm:** With lead and lag boilers are in operation, override supply HHW temp. to be 20 deg. F below setpoint and wait for 15 mins.	Lead and lag boilers operate continuously and an alarm is generated at the BAS.	

Functional Performance Testing Procedure

System:	Central Variable Volume Air Handling Systems	
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer	
Equipment Tag:	AC-1, AC-2, AC-3, AC-4 & AC-5	
Participants:	**Name**	**Organization**
Date:		
Comments:		

Sequence:

General:
The water-cooled rooftop direct expansion (DX) units (AC units) include high efficiency refrigeration, hot water preheat coils, supply and return or relief fans with variable frequency drives (VFDs), fully integrated economizers, outside air (OSA) monitoring stations (except AC-5), direct digital (DDC) controls and air filtration. Heat is rejected from the water-cooled condenser section to the cooling towers. These units have factory-installed ACL controllers with a Bacnet MSTP interface to the Siemens BAS.

Start/Stop:
The air handling unit is scheduled for automatic operation on a time of day basis for Occupied and Unoccupied modes. Within the Unoccupied mode, the system can enter Warm-Up mode when the space temperature is below setpoint or the Cool-Down mode when the space temperature is above setpoint, scheduled to initiate 1hour and 1-half before occupied mode to meet occupied setpoints. Within the Unoccupied mode, Night Heating and Night Cooling are available. Night Heating is available when the space temperature from three or more VAV zones with associated AC unit drops below 61 deg. F. Night Cooling is available when the space temperature from three or more VAV zones with associated AC unit increases above 82 deg. F. The latest start time is the scheduled occupancy for the space.

Warm-Up:
The AC-Unit is enabled and forced into Morning Warmup. The heating water system is enabled. The VAV boxes are set to heating mode and the VAV control dampers modulate to warm-up the space to the space day heating setpoint. Warm-Up mode ends when only two zones associated with the AC unit are 3 deg. F or less below the space day heating setpoint (70 deg. F), or when time reaches the scheduled occupancy during the Warm-Up mode. The VAV boxes control their own heating/cooling mode. The system is prevented from entering the Warm-Up mode during occupied hours.

Cool-Down:
This mode is enabled during Unoccupied Mode when the space is warm and the outdoor air is cool enough to cool the building using only economizer. The AC-Unit is enabled and Mechanical Cooling is locked out. The VAV control dampers modulate to cool-down the space to the space cooling setpoint. Cool-Down mode is enabled when the average space temperature is greater than the cooldown setpoint (initially 78 deg. F) and the outside air temperature is at least 10 deg. F colder than the average space temperature. This mode ends when the average space temperature is 5 deg. F less than the cooldown setpoint (initially 78 deg. F) or the outside air temperature is less than 5 deg. F colder than the average space temperature, or when time reaches the scheduled occupancy during the Cool-Down mode. The system is prevented from entering the Cool-Down mode during occupied hours.

Occupied:
The AC-Unit is enabled. During occupied mode, the VAV boxes control damper and the reheat coil control valves modulate to maintain the space setpoint.

Functional Performance Testing Procedure

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Equipment Tag:	AC-1, AC-2, AC-3, AC-4 & AC-5

Supply Air Temperature Setpoint
The supply temperature setpoint shall be reset from both the outdoor air temperature and the average zone temperature between the limits of 55-65 deg. F (adj.). The following matrix shall be used:

	OA Temp 30	60	90
Average Room Temp			
78	59	57	55
73	62	59.5	57
68	65	62	59

Preheat Coil Freeze Protection
The HW system is enabled if AC Unit low temperature detector trips.

Demand Control Ventilation
The minimum outside air setpoint is determined by the Siemens BAS. CO2 sensors located in high occupancy spaces detect the carbon dioxide concentration in the building. CO2 concentration shall be kept below 1,000 ppm differential relative to the ambient CO2 concentration outside by modulating the minimum outside air flow setpoint.

Unoccupied
The AC-Unit is disabled.

Night Heating:
The AC-Unit is enabled and forced into Morning Warmup. The supply air temperature setpoint is 85 deg. F. The heating water system is enabled. The VAV reheat control valves modulate as required and all VAV boxes are in heating mode. The VAV control dampers modulate to warm up the space to the space night heating setpoint of 64 deg. F. Night Heating mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 deg. F or less below the space heating setpoint (or 61 deg. F). Night heating mode ends when only two zones associated with the AC unit are below the space night heating setpoint (64 deg. F).

Night Cooling:
The AC-Unit is enabled. The VAV reheat control valves are closed (VAV boxes are in cooling mode). The VAV control dampers modulate to cool down the space to the space night cooling setpoint of 82 deg. F. Night Cooling mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 deg. F or more above the space cooling setpoint (or 85 deg. F). Night Cooling mode ends when only two zones associated with the AC unit are above the space night cooling setpoint (82 deg. F).

Unoccupied Override Switch
Selected room thermostat sensors shall have an override switch for each AC unit. Upon activation of the override switch during unoccupied hours, The AC-Unit is enabled and the VAV boxes and reheat coil control valves serving the respective quadrant shall modulate to maintain the day space cooling and heating setpoints. VAV boxes serving other floors shall remain in night mode unless an override switch or other switch in mode occurs.

Alarm & Safety Controls:
The following alarm points are monitored by the BAS:
1. Dirty Filter
2. VFD General Alarm
3. Supply Air Temperature Out of Range
4. Fan Status

Functional Performance Testing Procedure

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Equipment Tag:	AC-1, AC-2, AC-3, AC-4 & AC-5
Events	1: Unoccupied Mode/Night Heating/Night Cooling 2: Morning Warm-up/Cool-down 3: Occupied Mode 4: Resets/Overrides 5: Safeties/Alarms 6: Economizer Test

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS
Outside Air Temperature (F)	
Supply Air Temperatures (F)	
Return Air Temperatures (F)	
Supply Air Flow Rates (CFM)	
Return Air Flow Rates (CFM)	
Outside Air Flow Rates (CFM)	
CO2 Level (ppm)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
Supply Air Temp.		
Return Air Temp.		
CO2 Level		

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
Outside Air Dampers				
Return Air Damper				
Relief Air Damper				
CW control valve				
HHW control valve				

Status Check

Override control to each piece of equipment, note response.

Component	Responds?	Notes

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC-

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	1 a	**Unoccupied Mode:** With unit in occupied mode, override time clock to enable unoccupied mode	Outside air damper closed, return air damper open. Mechanical cooling disabled, supply and return fans OFF. CW and HHW control valves closed.	
☐	☐	1 b	**Night Heating:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below night htg setpt	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	
☐	☐	1 c	**Night Cooling:** With unit in unoccupied mode, override OAT to be below ave space temp. and space temp. of 3 zones to be 3 F above night clg setpt	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	
☐	☐	2 a	**Morning Warm-Up:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F below day htg setpt and time clock to be 95 mins. before occupancy	Outside air damper closed, return air damper open. HW system enabled. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in heating mode, reheat coils enabled and system operates until temp. of 2 zones are below night htg setpt.	
☐	☐	2 b	**Morning Cool-Down:** With unit in unoccupied mode, override space temp. of 3 zones to be 3 F above day clg setpt and time clock to be 95 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling is locked out. VAV boxes are in cooling mode and system operates until temp. of 2 zones are above night clg setpt.	
☐	☐	3 a	**Occupied: 1st Stage Cooling** With unit in unoccupied mode, override OAT to be below ave space temp. and time clock to be 5 mins. before occupancy	Outside air damper open, return air damper closed. Supply and return fans turn ON and mechanical cooling disabled. OA and RA dampers modulate to maintain SA Temp. to be at setpoint.	
☐	☐	3 b	**Occupied: 2nd Stage Cooling** With unit in occupied mode, override OAT to be above ave space temp.	Supply and return fans run continuously. Outside air damper closed to min. position, return air damper open. Mechanical cooling turns ON and modulate to maintain SA Temp. to be at setpoint.	

Functional Performance Test

System:	Central Variable Volume Air Handling Systems
Title:	Water-Cooled Rooftop Air Handling Units w/ HW preheat coil and enconomizer
Tag:	AC-

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	4 a	**Supply Air Temp. Reset:** With unit in occupied mode, override OAT and space temp. to simulate SAT reset strategy	The supply air temp. setpoint increases if OAT and/or Ave Space Temp. increase. Whereas SAT setpoint decreases if OAT and/or Ave Space Temp decrease.	
☐	☐	4 b	**Pre-heat Coil Operation:** With unit in occupied mode, override low temp. detector status to be low entering coil air temp.	Supply and return fans run continuously. HW system enabled. Outside air damper closed to min. position, return air damper open. HHW valve opens and modulate to maintain cooling coil entering air temp.to be above min. setpoint.	
☐	☐	4 c	**Demand Control Ventilation: CO2 Reset** With unit in occupied mode, override space CO2 level to be above setpt	Supply and return fans run continuously. Outside air damper opens from min. position and modulate to until space CO2 level is below setpoint.	
☐	☐	5 a	**Supply Fan Alarm:** With unit is running, override SF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☐	☐	5 b	**Return Fan Alarm:** With unit is running, override RF status to be OFF	Observe that the SF and RF stop and an alarm is generated at the BAS.	
☐	☐	5 c	**Compressor Alarm:** With unit in mechanical cooling mode, override compressor status to be OFF	Supply and return fans run continuously. Observe that the compressor stops and an alarm is generated at the BAS.	
☐	☐	5 e	**Smoke Detection Alarm:** With unit in occupied mode, activate supply air smoke detector	Upon smoke indication in the supply air duct, the SF and RF fan are truned OFF through a hardwire connection. An alarm is generated at the BAS.	
☐	☐	5 f	**High Static Press Alarm:** With unit is running, override static pressure limit switch status to be high SA pressure	SF & RF ramp down to min. speed and an alarm is generated at the BAS.	
☐	☐	5 g	**Freezestat Alarm:** With unit in occupied mode, trip the freezestat switch	Minimum outside air damper closed, economizer outside damper closed, relief air damper closed, return air dampers open. Supply fans run continuously and CHW control valve closed.	
☐	☐	5 h	**Communication Loss w/ BAS** With unit in occupied mode, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. The current mode of operation is maintained.	

Functional Performance Test - Economizer

Equipment Tag: AH-

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Remark / Other Observed System Responses
6a	**Simulate a cooling load and enable the economizer** *Overrides to simulate this mode:* Leave system in occupied mode. Simulate call for cooling thru DDC by setting temp. 5 F lower than currentspace set point temperature. If outdoor air temperature is lower than return air temperature, verify that economizer dampers are open for 100% outdoor air. Otherwise, use cold spray on outdoor air sensor to simulate condition. Then remove cold spray and verify that economizer dampers return to minimum air position. (else, use hand or hair dryer to warm the outdoor air sensor to simulate condition).	☐ Economizer damper modulates open to maximum position to provide 100% of design supply air quantity as outside air.	
		☐ Economizer damper returns to minimum outside air position.	
		☐ Return air damper modulates closed and is completely closed when economizer damper is 100% open.	
		☐ Economizer damper is 100% open before mechanical cooling is enabled.	
		☐ Relief is provided through barometric damper or powered relief (relief or return fan and exhaust damper).	
		☐ No heating provided.	
		☐ Mechanical cooling is only enabled if cooling space temperature setpoint is not met with economizer at 100% open.	
		☐ There are no signs of building overpressurization.	
6b	**Simulate a cooling load and disable the economizer** *Overrides to simulate this mode:* Use BAS to override OA temperature to be >65 F	☐ Economizer damper closes to minimum position.	
		☐ Return air damper opens to normal operating position.	
		☐ Relief fan (if applicable) shuts off or barometric relief dampers close. If system uses a return fan, the exhaust damper is shut.	
		☐ Mechanical cooling remains enabled until cooling space temperature setpoint is met.	

Functional Performance Testing Procedure

System:	VAVs	
Title:	VAV Boxes with/without reheat coil	
Eqipment Tag:	VAV -	
Participants:	**Name**	**Organization**
Date:		
Comments:		

Sequence:

Start/Stop
The air handling unit is scheduled for automatic operation on a time of day basis for Occupied and Unoccupied modes. Within the Unoccupied mode, the system can enter Warm-Up mode when the space temperature is below setpoint or the Cool-Down mode when the space temperature is above setpoint, scheduled to initiate 1hour and 1-half before occupied mode to meet occupied setpoints. Within the Unoccupied mode, Night Heating and Night Cooling (Siemens-BAS) are available. Night Heating is available when the space temperature from three or more VAV zones with associated AC unit drops below 61 F. Night Cooling is available when the space temperature from three or more VAV zones with associated AC unit increases above 82 F. The latest start time is the scheduled occupancy for the space.

Warm-Up
The VAV boxes are set to heating mode and the VAV control dampers modulate to warm-up the space to the space day heating setpoint. Warm-Up mode ends when only two zones associated with the AC unit are 3 F or less below the space day heating setpoint (70F), or when time reaches the scheduled occupancy during the Warm-Up mode. The VAV boxes control their own heating/cooling mode. The system is prevented from entering the Warm-Up mode during occupied hours.

Cool-Down
The VAV control dampers modulate to cool-down the space to the space cooling setpoint. Cool-Down mode is enabled when the average space temperature is greater than the cooldown setpoint (initially 78 Deg F) and the outside air temperature is at least 10 Deg F colder than the average space temperature. This mode ends when the average space temperature is 5 Deg less than the cooldown setpoint (initially 78 Deg F) or the outside air temperature is less than 5 Deg F colder than the average space temperature, or when time reaches the scheduled occupancy during the Cool-Down mode. The system is prevented from entering the Cool-Down mode during occupi

Occupied
During occupied mode, the VAV boxes control damper and the reheat coil control valves modulate to maintain the space setpoint.

Night Heating
The VAV reheat control valves modulate as required and all VAV boxes are in heating mode. The VAV control dampers modulate to warm up the space to the space night heating setpoint of 64 F. Night Heating mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 F or less below the space heating setpoint (or 61 Deg F). Night heating mode ends when only two zones associated with the AC unit are below the space night heating setpoint (64 Deg F).

Functional Performance Testing Procedure

System:	VAVs
Title:	VAV Boxes with/without reheat coil
Eqipment Tag:	VAV -

Night Cooling
The VAV reheat control valves are closed (VAV boxes are in cooling mode). The VAV control dampers modulate to cool down the space to the space night cooling setpoint of 82 F. Night Cooling mode is enabled when the space temperature from three or more VAV zones with associated AC unit are 3 F or more above the space cooling setpoint (or 85 Deg F). Night Cooling mode ends when only two zones associated with the AC unit are above the space night cooling setpoint (82 Deg F).

Unoccupied Override Switch
Selected room thermostat sensors shall have an override switch for each AC unit. Upon activation of the override switch during unoccupied hours, The AC-Unit is enabled and the VAV boxes and reheat coil control valves serving the respective quadrant shall modulate to maintain the day space cooling and heating setpoints. VAV boxes serving other floors shall remain in night mode unless an override switch or other switch in mode occurs.

Alarms
The following alarm points are monitored by the BAS:
1.Supply Air Temperature Out of Range

Events:
1: Unoccupied Mode
2: Warm-up/Cool-down Cycle
3: Occupied Mode
4: Unoccupied Manual Override
5: VAV Box Air Flow Capacity Test

Equipment Schedule — VAV -

CW System required on with Chiller operation regardless of building occupancy scedule.

DAY	DESIGN	ACTUAL
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters — VAV -

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Design	Value programmed in BAS

Sensor Installation Check — VAV -

Verify that sensor is installed and in an appropriate location. If calibration is in question, use a reference temperature or humidity sensor to test the following sensors. Place the reference sensor as close as possible to the tested sensor.

Sensor	Installation?	Location?	Notes
ZAT			
DAT			
SAT			

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadiquate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
VAV Damper				

Functional Performance Test

System:	VAVs
Title:	VAV Boxes with/without reheat coil
Tag:	VAV -

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**Unoccupied mode** *Overrides to simulate this mode*: Override time clock to enable unoccupied mode	☐ Damper closed. ☐ HW valve closed.	
2a	**Cool down** *Overrides to simulate this mode*: With unit in unoccupied mode, override time clock to enable morning cool down mode. Repeat the same procedure with night cooling mode.	☐ Damper opens ☐ HW valve closed.	
2b	**Warm up** *Overrides to simulate this mode*: With unit in unoccupied mode, override time clock to enable morning warm up mode. Repeat the same procedure with nighting heating mode.	☐ Damper in min. open position. ☐ HW valve opens.	
3a	**Occupied Mode: Cooling** *Overrides to simulate this mode*: With unit in occupied mode, override space temp to be higher than cooling setpt	☐ Damper modulates to maintain space temp setpt. ☐ HW valve closed.	
3b	**Occupied Mode: No heating & cooling** *Overrides to simulate this mode*: With unit in occupied cooling mode, override space temp to be within deadband	☐ Damper in min. open position. Min. Air Flow = [___CFM] ☐ HW valve closed.	
3c	**Occupied Mode: Heating** *Overrides to simulate this mode*: With unit in occupied mode, override space temp to be lower than heating setpt	☐ Damper in min. open position. ☐ HW valve modulates to maintain space temp setpt.	
4	**Unoccupied Manual Override** *Overrides to simulate this mode*: With unit in unoccupied mode, push the override button or override the VAV zone to be override mode	☐ Unit operates in occupied mode for 2 hours.	
5	**VAV Air Flow Capacity Test** *Overrides to simulate this mode*: With SA duct static press setpt being met, override space temp to be 10 deg. F above clg setpt	☐ Observe that the damper goes to max. as expected. ☐ When air flowrate is steady, measure the max. CFM achieved. ☐ HW valve closed.	

Functional Performance Testing Procedure

System:	Server Room Air Conditioning Systems	
Title:	Water Cooled CRAC Units w/ DX cooling and Steam Humidifier	
Equipment Tag:	CRAC-1 to 3, DC-1 & 2	
Participants:	**Name**	**Organization**
Date:		
Comments:		

Sequence:

General:
This system is locally controlled by the Liebert system and monitored via Modbus integration to the Siemens BAS. The main computer room is located on the 5th floor and will be provided with Liebert water-cooled Deluxe System 3 units, or equal. N+1 configuration consists of three units, 15 nominal tons each. Units are complete with dual refrigeration circuits, humidifiers, seismic floor stands and DOC interface. Condenser water will be routed to each unit from the mechanical shaft risers. Ventilation will be provided by the unit AC-2 during scheduled occupancy.
As an added level of redundancy, a Drycooler (DC-1, 2) system at the 4th level roof serves the CRAC units. The system will provide heat of rejection should the building cooling tower system fail or be taken off-line for major maintenance. The backup system includes two backup drycoolers, tie-ins to CW roof piping, 2 changeover valves and a central pumping package.

Start/Stop
The factory mounted local controller switches lead and lag CRAC units. The lead CRAC unit rotation occurs every 150 hours. The factory mounted local controller located on the lead CRAC unit is enabled to start by the when the space temperature is above 69 deg. F. When one CRAC unit is in operation, the space setpoint shall be 70 deg. F. The lag CRAC unit is enabled to start when the space temperature is above 71 deg. F. When two CRAC units are in operation, the space setpoint shall be 72 deg. F. The local CRAC controller provides unit control to maintain the space temperature and humidity setpoints. Should the lead CRAC fail to start, an alarm shall be sent to the BAS system and the lag CRAC becomes the lead CRAC. The backup CRAC then becomes the lag CRAC.

Humidity Setpoint
The CRAC humidifiers shall maintain a setpoint of 45% RH.

Normal Operation
During normal operation, the building loop condenser water shall bypass the drycooler (DC) system and be directed to the CRACs. The two-way CRAC control valve shall open upon activation of the respective CRAC unit. The control valve shall shut upon CRAC unit shutdown.

Dry Cooler Operation
Upon failure of the condenser water system, the CRAC condenser water shall bypass the building loop condenser water system and be directed to the dry cooler system. Upon switch over to Dry Coolers, the CRAC units momentarily shut off to prevent high head pressure trip from the risk of losing water flow. The dry coolers are staged to provide 120 deg. F condenser water to the CRACs by the local dry cooler controller. The CRAC lead/lag operation and the CRAC control valves operate as during normal operation.
Start/Stop
The drycooler system is enabled when the following conditions are met:
1. The CRAC system is enabled AND
2. Both cooling towers have failed or are off OR
3. All three tower loop condenser water pumps have failed or are off OR
4. All three building loop condenser water pumps have failed or are off OR
5. The building loop condenser water exceeds 90 F for 10 minutes AND
6. One CRAC has gone off on high head or failed

Functional Performance Testing Procedure

System:	Server Room Air Conditioning Systems
Title:	Water Cooled CRAC Units w/ DX cooling and Steam Humidifier
Equipment Tag:	CRAC-1 to 3, DC-1 & 2
	Alarms 1. If the lead CRAC unit fails to start, an alarm is generated by the BAS. 2. If the space temperature setpoint exceeds 72 deg. F for 10 minutes, an alarm is generated. 3. If the space humidity setpoint exceeds 55% RH for 10 minutes, an alarm is generated. 4. If the lead DC unit fails to start, an alarm is generated by the BAS. The lead DC unit is locked out and the lag DC unit becomes the lead. **Emergency Power Mode** Upon loss of normal power, Lead and lag CRAC units and drycoolers are powered.
Events	1: Startup/Shutdown 2: Cooling Mode 3: Humidifying Mode 4: Changeover/Safeties 5: Alarms 6: Drycoolers

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS
Space Temperature (F)	
Space Relative Humidity (%)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
Space Temp		
Space Humidity		
Smoke Alarm Detector		
Water Detection Sensor		

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
CW supply 3-way valve				
CW return 3-way valve				

Status Check

Override control to each piece of equipment, note response.

Component	Responds?	Notes
Normal/Bypass Mode		

Functional Performance Test

System:	Server Room Air Conditioning Systems
Title:	Water Cooled CRAC Units w/ DX cooling and Steam Humidifier
Tag:	CRAC-1 to 3

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	1	**Startup/Shutdown:** Verify that CRAC unit can be operated in each of the three modes listed below, 1. Automatical control based on time schedule by BAS; 2. Override ON/OFF thru BAS; 3. Manual start/stop by using unit panel "ON/OFF" button.	Unit turns ON and OFF in accordance with the time schedule Unit responses to override from BAS, and reset to original operation mode after the override is removed Observe that unit truns ON and "Local ON" is shown on BAS screen. After the "ON/OFF" is pressed again, unit turns OFF and "Local OFF" alarm is generated from BAS.	
☐	☐	2 a	**No Cooling:** With unit in unoccupied mode, override space temp to be within deadband and time clock to be 5 minutes before occupancy	Lead CRAC is enabled. Supply fan starts. Compressor OFF and DX cooling sequence inactive. Humidifier is OFF.	
☐	☐	2 b	**1st Stage Cooling:** With lead unit in occupied mode, override space temp to be 69 deg. F	Lead unit supply fan runs continuously. Compressor ON and DX cooling sequence active. Humidifier is OFF.	
☐	☐	2 c	**2nd Stage Cooling:** With lead unit in occupied cooling mode, override space temp to be 71 deg. F	Lead unit operates continuously in cooling mode. Humidifier is OFF. Lag unit is enabled. Supply fan is ON. Compressor ON and DX cooling sequence active. Humidifier is OFF.	
☐	☐	3	**Humidifying Mode:** With lead and lag units in operation, override space humidity to be above setpt	Supply fans runs continously. Humidifiers are ON and modulate output to maintain humidity at setpt.	
☐	☐	4 a	**Operation Rotation:** With lead and lag units in operation, activate the unit rotation sequence	Lead unit shuts down and standby unit starts. Lag unit becomes 'Lead' unit, standby unit becomes 'Lag' unit, and lead unit is turned to be 'standby' mode.	
☐	☐	4 b	**Drycooler Mode:** With unit in operation, override CW loop to be 'Bypass' mode	CRAC unit shuts down. CW supply and return control valves rotate to drycooler configuration. Drycoolers are enabled. CRAC unit resumes operation.	

Functional Performance Test

System:	Server Room Air Conditioning Systems
Title:	Water Cooled CRAC Units w/ DX cooling and Steam Humidifier
Tag:	CRAC-1 to 3

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	4 c	**Communication Loss w/ BAS** With unit in operation, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. Current mode of operation continues.	
☐	☐	4 d	**Power Loss** With unit in operation, open the disconnect to simulate power loss. (resume power after 40 sec)	Observe unit shuts down and an alarm is generated at BAS. After the power is resumed for 3 minutes, the unit starts normally and operates with previous mode of operation.	
☐	☐	5 a	**Supply Fan Alarm: Loss of Air Flow** With unit in operation, override fan status to be OFF	Observe unit shuts down and an alarm is generated at BAS.	
☐	☐	5 b	**Compressor Alarm:** With unit in cooling mode, override compressor status to be OFF	Observe supply fan runs continuously. An alarm is generated at the BAS.	
☐	☐	5 c	**Humidifier Alarm:** With unit in humidifying mode, override humidifer status to be OFF	Observe supply fan runs continuously. An alarm is generated at the BAS.	
☐	☐	5 d	**Smoke Detection Alarm:** With unit in operation, override supply air smoke detector status to be FIRE	Upon smoke indication in the supply air duct, supply fan shall be stopped through a hardwire connection. Unit status will be changed to unoccupied mode.	
☐	☐	5 e	**Water Leak Alarm:** With unit in operation, override water detection sensor status to be having water leakage	Observe supply fan runs continuously. Compressor and humidifier are OFF and disabled. An alarm is generated at the BAS.	
☐	☐	5 f	**High/Low Temp Alarm:** With unit in operation, override High Temp alarm setpt to be below space temperature. Repeat similar procedure for Low Temp. alarm setpt.	Observe supply fan runs continuously. An alarm is generated at the BAS.	
☐	☐	5 g	**High/Low Humidity Alarm** With unit in operation, override High Humidity alarm setpt to be below space humidity. Repeat similar procedure for Low Humidity alarm setpt.	Observe supply fan runs continuously. An alarm is generated at the BAS.	

Functional Performance Test - Drycoolers

Equipment Tag:		DC-1 & 2	
#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
6a	**Unoccupied Mode - Normal**	☐ CW Supply and Return 3-way valves in 'Normal' positions.	
	Overrides to simulate this mode: With building CW system in operation, override CRAC time clock to be 5 minutes before occupancy	☐ Drycoolers are disabled.	
		☐ Cooler fans OFF	
		☐ Cooler pumps OFF	
6b	**Occupied Mode - Bypass**	☐ CW Supply and Return 3-way valves in 'Bypass' positions.	
	Overrides to simulate this mode: Override CRAC CW supply to be 'Bypass' mode, start CRAC system	☐ Drycoolers are enabled.	
		☐ Cooler fans OFF	
		☐ Cooler pumps ON	
6c	**1st Stage Cooling (Bypass Mode)**	☐ CW Supply and Return 3-way valves in 'Bypass' positions.	
	Overrides to simulate this mode: With CRAC in Bypass mode, override space temp to be 69 deg.F	☐ Drycoolers are enabled.	
		☐ Cooler fans ON and running at low speed.	
		☐ Cooler pumps run continuously	
6d	**2nd Stage Cooling (Bypass Mode)**	☐ CW Supply and Return 3-way valves in 'Bypass' positions.	
	Overrides to simulate this mode: With CRAC in Bypass mode, override space temp to be 71 deg.F	☐ Drycoolers are enabled.	
		☐ Cooler fans ON and modulate to maintain CWS temp at setpt.	
		☐ Cooler pumps run continuously	
6e	**Humidifying (Bypass Mode)**	☐ CW Supply and Return 3-way valves in 'Bypass' positions.	
	Overrides to simulate this mode: With CRAC in Bypass mode, override space temp to be within deadband and humidity to be below setpt	☐ Drycoolers are enabled.	
		☐ Cooler fans OFF	
		☐ Cooler pumps run continuously	
6f	**Interlock Sequence**	☐ CW Supply and Return 3-way valves in 'Normal' positions.	
	Overrides to simulate this mode: With building CW system in unoccupied mode, override CW 3-way valves to be 'Normal' mode and CRAC time clock to be 5 minutes before occupancy	☐ Drycoolers are disabled.	
		☐ Cooler fans OFF	
		☐ Cooler pumps OFF	

Functional Performance Testing Procedure

System:	Makeup Air Unit	
Title:	Makeup Air Unit for Kitchen Exhaust	
Equipment Tag:	MUA-1	
Participants:	**Name**	**Organization**
Date:		
Comments:		

Sequence:

General:
The MUA-Unit is located on the 3rd floor roof. Unit contains a 30% pre-filter, 2-stage gas furnace, and stainless steel heat exchanger. Unit serves compensating hood for 1st floor kitchen and interlocked with Gaylord (or equal) Control Panel & hood exhaust fan (EF-7).

Start/Stop
The supply fan in the make up air unit is enabled/disabled by the BAS.

Smoke Detector
Upon detection of smoke in the discharge of MUA-unit, the MUA supply fan is shut down upon alarm. This function is not provided by the BAS.

Heating Setpoint
The gas-fired furnace shall stage to maintain a supply air temperature setpoint of 65 F.

Alarms
The following alarm points are monitored by the BAS:
1. Dirty Filter
2. Fan Status

Emergency Power Mode
Upon loss of Normal Power, MUA unit shuts down.

Events
1: Startup/Shutdown
2: Unoccupied Mode
3: Occupied Mode
4: Safeties/Alarms

Operation Schedule

Record programmed schedule.

	Schedule	**Notes**
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	**Value programmed in BAS**
Supply Air Temp (F)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	**Actual Location**	**Notes**
SA Temp		

Functional Performance Test

System:	Makeup Air Unit
Title:	Makeup Air Unit for Kitchen Exhaust
Tag:	MUA-1

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	1	**Startup/Shutdown** Verify that the unit can be operated in each of the three modes listed below, 1. Automatically based on time schedule in BAS 2. Manually using local "ON/OFF" switch 3. Override ON/OFF thru BAS.	System turns ON and OFF in accordance with the interlock time sequence with Kitchen EF. Observe that unit truns ON and "Local ON" is shown on BAS screen. After the "ON/OFF" is pressed again, unit turns OFF and "Local OFF" alarm is generated at BAS. It responses to override from BAS, and reset to original operation mode after the override is removed.	
☐	☐	2	**Unoccupied Mode** With unit is running, override MAU status to be OFF.	Observe that MAU turns off and OA damper close.	
☐	☐	3 a	**Occupied Mode - Heating** With unit in operation, override supply air temp to be 5 deg. F below htg setpt	Observe that the fan runs continuously. The gas burner turns on. MUA controls modulate the burner firing rate to maintain supply air temp at setpoint.	
☐	☐	3 b	**Occupied Mode - No heating** With unit in heating mode, override supply air temp to be 5 deg. F below htg setpt	Observe that the gas burner turns OFF and the fan runs continuously.	
☐	☐	4 a	**Fan Alarm** With unit is running, override fan status to be OFF	The gas burner shuts off. Fan stops and an alarm is generated at BAS.	
☐	☐	4 b	**Smoke Detection Alarm** With unit is running, activate the supply duct smoke detector.	Upon smoke indication in the supply air duct, supply fan shall be stopped through a hardwire connection. Unit status will be changed to unoccupied mode.	
☐	☐	4 c	**Supply Air Temp Alarm** With unit in heating mode, override supply air temperature to be exceeded active setpoint by +/- 10 deg. F	The fan runs continuously and the gas burner turns off. An alarm is generated at BAS.	

Function Performance Testing Procedure

System:	General Exhaust Fans	
Title:	Exhaust Fans	
Equipment Tag:	EF-	
Participants:	**Name**	**Organization**
Date:		
Comments:		
Sequence:	**GENERAL** **Start/Stop** Exhaust Fan (EF-1, 2, 3, 5,10,11,13 thru 17) is enabled/disabled by the BAS. Exhaust Fan (EF-7, 8) is enabled/disabled by kitchen hood control panel. Exhaust Fan (EF-4, 6, 9) is enabied/disabled by a wall or door switch. Exhaust Fan (EF-19, 20) is enabled/disabled by local wall t'stat. Exhaust Fan (EF-12) is enabled/disabled by Fire Pump Alarm Panel. **ALARMS** (EF-1, 2, 3, 5,10,11,13 thru 17) The following alarm points are monitored by the BAS: 1. Upon fan failure to start, an alarm is generated. **EMERGENCY POWER MODE** Upon loss of Normal Power, all EF are disabled.	
Events:	Basic space exhaust fans in various control arrangements, from toggle switch operation, to equipment interlocks, to occupancy controlled.	

Operating Schedule - *Record time-of-day and setpoints and note any deviation from DESIGN*

	Design	Actual	Notes
Mon - Fri			
Saturday			
Sunday			
Holidays			

Prefunctional Checklist

Note: whether the sensor is installed, and if so, if it is in an appropriate location. If indicated, use a reference sensor to test the following sensors. Place the reference sensor as close as possible to the tested sensor.

Device/Sensor	Installation?	Location/device	Notes
Power to Unit			
Interlocks			
ON/OFF Switch			
Wheel rotation			
Thermostat			

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. **Note:** excessive linkage slop and inadiquate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
Exhaust Damper	Yes	Yes	open	

Control Parameters

BAS / programmable T-stat / other

Record values for current setpoints, control parameters, limits, delays, lockouts, etc.and note any deviation from design ().

Parameter	per Design	Observed
EF-19	Thermostat	
EF-20	Thermostat	

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-7

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-8

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-4

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-6

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-9

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-19

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-20

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Test - Exhaust Fan

Equipment Tag: EF-1, 2, 3, 5, 10, 11, 13, 14, 15, 16 & 17

#	Simulation Mode/Test	Desired System Response (check box if observed) ☑	Other Observed System Responses
1	**General Control - Interlock with occupancy**	☐ Fan stops - status OFF	
	Overrides to simulate this mode: Stop FAN by changing the Occupancy Schedule	☐ Backdraft damper closes	
2	**General Control - Interlock with equipment /service**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Make this observation when testing fans in unoccupied mode. Equipment Switch Toggle On, Off; Service Toggle Enable, Disable	☐ Fan comes on when equipment on /service enable	
		☐ Fan stops when equipment off /service disable.	
3	**General Control - wall mounted thermostat**	☐ Changing Occupancy has no effect on the fan	
	Overrides to simulate this mode: Turn thermostat higher than room temp, then lower than room temp.	☐ Fan comes on when thermostat calls for it.	
		☐ Fan stops when set higher than room temperature	
		☐ Fan starts when set lower than room temperature	
4	**General Control - No control**	☐ Changing Occupancy has no effect on the fan, fan always on	
	Overrides to simulate this mode: Make this observation when testing exhaust fans in unoccupied mode	☐ Fan always on	
		☐ Backdraft damper is open & does not impede air flow	
5	**Fan control by local, dedicated toggle switch**	☐ Switch in 'ON' position - Fan 'ON'	
	Overrides to simulate this mode: Toggle ON - OFF	☐ Switch in 'OFF' position - Fan 'OFF'	
		☐ System turns OFF when manual override time period expires	
6	**Interlock Sequence**	☐ Fan starts when call on by interlock sequence	
	Overrides to simulate this mode: Set controlling equipment ON, verify if exhaust fan should be 'ON' or 'OFF'? Start test with exhaust fan 'ON'. Switch status of controlling equipment & note initial & final status.	☐ Fan stops when called off by interlock sequence	
		☐ Sequence verified	
		☐ Power actuated/gravity damper operation verified	

Notes:

Functional Performance Testing Procedure

System:	Water Source Heat Pump	
Title:	Water Cooled Package Air Conditioning Units	
Equipment Tag:	PCU-1 to 18, 20, 22, 24, 25 & 26	
Participants:	**Name**	**Organization**
Date:		
Comments:		

Sequence:

Package Cooling Units (water-cooled)
The Package AC Units (PCU) are located on all floors above a ceiling. These units provide constant volume cooling to Data, Electrical, control and like rooms. Each PCU is equipped with a water-cooled DX cooling system.

Start/Stop
Each AC unit is enabled/disabled by the BAS. Typically, these units are always enabled.

Smoke Detector
PCU-2, 3 &13 is shut down upon detection of smoke in the supply duct. This function is not provided by the BAS.

Alarm & Safety Controls
The following alarm points are monitored by the Siemens BAS:
1. If the space temperature setpoint is exceeded for more than 10 minutes, an alarm is generated.

Emergency Power Mode
Upon loss of Normal Power, PCU-2, 3,6,7,10,11,15,16,18,22 & 25 units continue to operate on emergency power at full capacity. Remaining PCU units to shut down.

Events
1: Startup/Shutdown
2: Occupied Mode
3: Safeties/Alarms

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

DDC Parameters

Record values for current setpoints, control parameters, limits, delays, lockouts,etc.and note any deviation from design.

Parameter	Value programmed in BAS
Supply Air Temperatures (F)	
Space Air Temperature (F)	

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
SA Temp		
Space Air Temp.		

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
CW control valve				

Functional Performance Test

System:	Water Source Heat Pump
Title:	Water Cooled Package Air Conditioning Units
Tag:	PCU-1 to 18, 20, 22, 24, 25 & 26

Pass	Fail	Event #	Description of Event Testing	Expected Results	Remarks
☐	☐	1	**Startup/Shutdown:** Verify that the unit can be operated in each of the following modes listed below, 1. Automatical control based on time schedule in BAS; 2. Override ON/OFF thru BAS.	Unit turns ON and OFF in accordance with the time schedule. Unit responses to override from BAS, and reset to original operation mode after the override is removed.	
☐	☐	2 a	**Occupied Mode: No Cooling** With unit in unoccupied mode, override space temp to be within deadband and time clock to be 5 minutes before occupancy	Unit is enabled and supply fan turns ON. Compressor is OFF, CW control valve is closed and DX cooling sequence is inactive.	
☐	☐	2 b	**Occupied Cooling Mode:** With unit in occupied mode, override space temp to be above clg setpt	Supply fan runs continuously. Compressor is ON, CW control valve is open and DX cooling sequence is active.	
☐	☐	3 a	**Communication Loss w/ BAS** With unit in operation, disconnect the BAS LAN wires at the unit. (re-connect after test)	Unit continues to run and operate normally. Current mode of operation continues.	
☐	☐	3 b	**Power Loss** With unit in operation, open the disconnect to simulate power loss. (resume power after 40 sec)	Observe unit shuts down and an alarm is generated at BAS. After the power is resumed for 3 minutes, the unit starts normally and operates with previous mode of operation.	
☐	☐	3 c	**Supply Fan Alarm: Loss of Air Flow** With unit in operation, override fan status to be OFF	Observe unit shuts down and an alarm is generated at BAS.	
☐	☐	3 d	**Compressor Alarm:** With unit in cooling mode, override compressor status to be OFF	Observe supply fan runs continuously. Compressor shuts down and CW control valve closes. An alarm is generated at the BAS.	
☐	☐	3 e	**Smoke Detection Alarm:** With unit in operation, activate the supply air smoke detector	Upon smoke indication in the supply air duct, supply fan shall be stopped through a hardwire connection. Unit status will be changed to unoccupied mode.	
☐	☐	3 f	**Condensate Overflow Alarm:** With unit in cooling mode, actative condensate pan water overflow sensor	If an overflow condition is sensed in the condensate pan, the compressor shuts down and an alarm is generated at the BAS.	
☐	☐	3 g	**High Temp Alarm:** With unit in operation, override space temp to be above high temp alarm setpt and wait for 5 minutes	Observe unit shuts down and an alarm is generated at the BAS.	

STANDARD COMMISSIONING PROCEDURE FOR LIGHTING SWEEP CONTROLS

Participants:	Name	Organization
Date:		

General Notes:

1. This is a generic test procedure for lighting sweep control systems. If the complexity, configuration, or other aspects of a specific project require substitute tests or additional tests, explain on the comments sheets, and attach the additional test procedures and field data. Use additional copies of this procedure as required for the total number of zones to be commissioned.
2. In all test sections, circle or otherwise highlight any responses that indicate deficiencies (i.e. responses that don't meet the criteria for acceptance). Acceptance requires correction and retest of all deficiencies, as defined in each test section under "Criteria for Acceptance" or "Acceptance". Attach all retest data sheets. Complete the Deficiency Report Form for all deficiencies.
3. This Commissioning Procedure does not address fire and life safety or basic equipment safety controls.
4. To ensure that this Commissioning Procedure will not damage any equipment or affect any equipment warranties, have the equipment manufacturer's representative review any interventive test procedures prior to execution.

OPERATOR INTERVIEW (Existing Buildings Only):
Determine from a discussion with the building operator whether the lighting sweep controls are operating properly to the best of their knowledge. Note any known problems, and possible solutions.

_____
_____
_____
_____
_____
_____

LIGHTING ZONE SCHEDULE:
For the purposes of this commissioning procedure, a lighting zone is defined as a group of luminaries that are controlled by a single schedule output. In cases of split wiring, a single building space may have two or more zones.

Sampling: If there are more than 8 zones in the building, you may select a sample for the following performance tests. The sample should include at least 10% of the total number of zones, or 8 zones, whichever is greater. Zones should be selected from different areas of each floor, and from different floors. Note in the table below which zones are selected for the sample.

Criteria for Acceptance: Lighting zoning must be in accordance with submittals as approved by Designer and Commissioning Agent.

ZONE #	SAMPLE ZONE? (✓)	DESCRIPTION OF LOCATION	CIRCUIT # (if available)

ZONE #	SAMPLE ZONE? (✓)	DESCRIPTION OF LOCATION	CIRCUIT # (if available)

COMMENTS ON ZONING (add more sheets if needed):

ZONE # COMMENT

INSTALLATION VERIFICATION:
Instructions: Under each zone write "Y" for yes, "N" for no, "NA" for not applicable, or a number to refer to any needed comments. Explain any “N” answers in the comment section. If other information is requested, write the appropriate values.

Criteria for Acceptance: All items require answers of “Y” (or “NA”, where relevant) except where other criteria are noted.

DESCRIPTION	ZONE #								
	General								
1. Are lighting schedules programmable with a microprocessor-based central processing unit (CPU)?									
2. Does CPU allow separate weekday, weekend, & holiday schedules?									
3. Verify battery backup by interrupting power to the CPU and restoring power. Do schedules remain intact? [1]									
4. Is zone less than 2500ft^2 in area?									
5. Method of override (“T” for telephone link, “L” for latching/smart switch, “S” for simple button or switch). Acceptance: per approved submittals.									
6. Override method compatible with CPU?									
7. Override controls no more than 2 zones?									
8. Override located within general area of zone(s) controlled?									
9. System provides warning to occupants prior to lights being swept off?									
10. Schedule & override time period are reasonable for zone occupancy pattern?[2]									
11. Override time period, minutes. Acceptance: <120 minutes [2]									
12. Occupants have been explained the intent & operation of the sweep system?									
13.									

Notes To Table:
[1] Don’t do this test unless you are sure the CPU is equipped with battery backup, and that the backup is supposed to keep schedule and other critical programming intact. Before doing test, explain to the building operator that failure of the test may mean loss of programming, and get permission to proceed.
[2] Answer in the “General” column only if a single schedule and override period applies to all zones; otherwise answer for each zone.

COMMENTS ON INSTALLATION VERIFICATION CHECKLIST ITEMS (add more sheets if needed):

ITEM #	ZONE #	COMMENT

FUNCTIONAL PERFORMANCE VERIFICATION:

The following section is a series of field tests that are intended to verify that the lighting sweep controls operate as they were intended to operate by the manufacturer and designer. Under each zone write "Y" for yes, "N" for no, "NA" for not applicable, or a number to refer to any needed comments. Explain any “N” answers in the comment section. If other information is requested, write the appropriate values. If you were not able to complete a test, write "ND" for not done, and explain in a comment.

Lighting Sweep Schedule Tests: Perform the following tests by monitoring and/or observing each lighting zone under actual operation. If the actual control sequence differs from that implied by the tests, attach a description of the control sequence, the tests that were done to verify the sequence, and your conclusions. It is permissible to adjust the programmed schedules and override periods for easier testing. If this is done, reprogram to the original schedules and override periods, or as directed by the building operator, at the conclusion of testing. Use of light loggers or current dataloggers over a one week period to document operation is recommended, though visual observation is acceptable. Annotate any logger data and graphs so that it is clear what the data are proving, and attach these to this form. Energy Management System trend logs of EMS outputs or schedule print-outs are not acceptable as proof of operation.

Criteria for Acceptance: All items require answers of “Y” (or “NA”, where relevant) except where other criteria are noted.

ZONE #								
1. Lights in zone are turned off at scheduled time?								
2. Lighting sweep is preceded by occupant warning (blinking of lights, etc.)?								
3. Override turns on zone lights only?								
4. Lights turned on by override are turned off after programmed override period?								
5. If space has split wiring, inboard and outboard lights are properly sequenced?								
6. If there is a keyed whole floor switch (for cleaning staff, etc.), this is also swept off?								
7. If HVAC terminal units also controlled by the sweep, units go to unocc. mode when swept off & go to occ. mode by override?								
8.								
9.								

COMMENTS ON FUNCTIONAL PERFORMANCE VERIFICATION ITEMS (add more sheets as needed):

ITEM #	ZONE #	COMMENT

FUNCTIONAL PERFORMANCE TEST
LIGHTING OCCUPANCY SENSOR CONTROLS

Project Name:	Caltrans District 3 - Headquarters Building, Marysville
Test Date/Time:	
Participant (commissioning):	
Participant (contractor):	

Part 1:
Verify that occupancy sensor controls have been installed for all lighting fixtures that have occupancy sensor control indicated in the construction documents (typically shown on lighting plans).

___ Verified
___ Not verified. Explain:

Part 2:
Verify that installed sensors match specifications in the construction documents.
(If there are more that two sensor types on the project, then use a separate sheet)

	As Found	**Meets Design? (yes/no/explain)**
Manufacturer:		
Model number:		
Type:	☐passive infrared ☐ultrasonic ☐dual-mode	
Mounting location:	☐ceiling ☐wall ☐other:	

	As Found	**Meets Design? (yes/no/explain)**
Manufacturer:		
Model number:		
Type:	☐passive infrared ☐ultrasonic ☐dual-mode	
Mounting location:	☐ceiling ☐wall ☐other:	

Part 3:

Verify that sensors have been properly installed and adjusted.
(use additional sheets as needed)

A	B	C	D	E
Room ID/ Desc.	**Verify Sensitivity ***	**Verify Time Delay**	**Findings/ Corrections**	**Pass/ Fail**
	☐ Detects minor motion throughout room ☐ Does not detect motion in adjacent areas Note final sensitivity setting: _____	Per design: ____min. As found: ____min. As adjusted:____min.		
	☐ Detects minor motion throughout room ☐ Does not detect motion in adjacent areas Note final sensitivity setting: _____	Per design: ____min. As found: ____min. As adjusted:____min.		
	☐ Detects minor motion throughout room ☐ Does not detect motion in adjacent areas Note final sensitivity setting: _____	Per design: ____min. As found: ____min. As adjusted:____min.		
	☐ Detects minor motion throughout room ☐ Does not detect motion in adjacent areas Note final sensitivity setting: _____	Per design: ____min. As found: ____min. As adjusted:____min.		
	☐ Detects minor motion throughout room ☐ Does not detect motion in adjacent areas Note final sensitivity setting: _____	Per design: ____min. As found: ____min. As adjusted:____min.		

Notes/Instructions:

A Record room ID number or name from plans.
Indicate space type, such as enclosed office, conference room, corridor, or toilet.

B If sensor LED indicator does not light with minor room motion, then increase sensitivity setting.
If sensor LED indicator lights with motion in adjacent areas, then reduce sensitivity setting.
When sensor detects minor room motion and not adjacent space motion, note the sensitivity setting (%).
Verify that air diffusers close to the sensor do not create nuisance trips.

Functional Performance Testing Procedure

System:	Domestic Hot Water System	
Title:	Domestic Hot Water Heater w/ storage, circulating pump	
Equipment Tag:	WH-3	
Participants:	**Name**	**Organization**
Date:		
Comments:		
Sequence:	Typical HW circulating system pumps hot water from the water heater, through the hot water piping, and on back to the water heater through an return line that runs from the furthest fixture back to the water heater. It provides nearly instant hot water at the fixtures, but it is very inefficient due to operation of the hot water pump and the heat energy lost from the piping. To minimize the energy waste by hot water pump circulating system timers are used for circulating pumps to shut the HW pump off during hours when no one normally uses HW - i.e. midnight to 6:00 a.m. Temperature sensing circuits are used to shut the HW pump off once the water temperature reaches a pre-set temperature such as 125 F and then starts the pump back up when the water temperature in the pipe drops below a second set point such as 110 F. **Alarm & Safety Controls:** DHW heater is monitored for status and alarm. Alarms shall be generated at host computer (BAS).	
Events	Test pressure, response to varying loads, water temperature and wait time at remote outlets, T&P valve operation, recovery time & temperature, overshoot, heat trap operation, proper drainage, etc.	

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
Aquastat		
T&P Relief Valve		
Circulating Pump		
Thermometer		
Sacrificial Anode		

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes
Gas/Air Mixing Damper				

Status Check

Override control to each piece of equipment, note response.

Component	Responds?	Notes
Circulating Pump		

Functional Performance Test - Domestic Hot Water System

Equipment Tag: WH-3

#	Simulation Mode/Test	Desired/Expected System Response (check box if observed) ☑	Remark / Other Observed System Responses
1	**Pressure & Temperature Verifications** *Procedure to simulate this mode:* Fill the system with water & document the observations	☐ Verify that system pressure is maintained. Pressure = _____ ☐ As the water is circulated, confirm that the temperature set point is maintained. Temperature = _____ ☐ Verify that T&P pop-off valve is safely drained to the nearest floor drain. ☐ Verify operation of T&P pop-off valve by lifting a manual release lever. Thermostat operates correctly. (there is a knob that allows you to set the temperature to warm, med or hot) ☐ Verify burner comes on when the tank drops below set point temperature. ☐ Verify the thermostat shuts off the burner when set point temperature is reached.	
2	**System-wide temperature checks.** Verify hot water temperature and wait times for hot water at different locations. Make note in the 'OTHER OBSERVED SYSTEM RESPONSES' column.	☐ Measure temperature at a statistically significant portion of outlets. ☐ Make note of any dead spots. ☐ Make note of any low-water temperatures. ☐ Make note of any long wait times for hot water at remote locations.	
3	**Recovery tests** *Overrides to simulate this mode:* Drain the hot water in order to simulate the maximum, and the resulting temperature recovery.	☐ Measure maximum recovery temp = _____ ☐ Measure the final recovery temp = _____ ☐ Verify correct operation of Heat Traps.	
4	**Anti-scalding & temperature control tests** *Overrides to simulate this Test:* Allow the system to return to set point.	☐ Verify the system return to set point with minimal overshoot = _____ ☐ Verify that overshoot observed is within norm and would not cause scalding. ☐ Verify all mixing valves should be confirmed to operate correctly prior to occupancy.	
5	**Hot Water Circulating System Tests (System with hot water return)** Verify the type of HW recirculation control installed and test its components. 1. If the circulator is controlled by timer verify timer settings - ON time vs. OFF time & compare with facility's peak period of HW demand. 2. If the circulator is controlled	☐ Verify that the circulating pump is operational. ☐ Set timer to a short OFF period & observe pump stop/start operation. ☐ Adjust temp. sensing circuit settings using the aquastatto simulate conditions for pump's ON/OFF operation. Observe temp. values of ON/OFF points. Adjust as needed.	

Functional Performance Testing Procedure

System:	Domestic Hot Water System (Electric)	
Title:	Domestic Hot Water Heater w/ storage, circulating pump	
Equipment Tag:	WH-1, WH-2 & CP-1	
Participants:	**Name**	**Organization**
Date:		
Comments:		
Sequence:	Typical HW circulating system pumps hot water from the water heater, through the hot water piping, and on back to the water heater through an return line that runs from the furthest fixture back to the water heater. It provides nearly instant hot water at the fixtures, but it is very inefficient due to operation of the hot water pump and the heat energy lost from the piping. To minimize the energy waste by hot water pump circulating system timers are used for circulating pumps to shut the HW pump off during hours when no one normally uses HW - i.e. midnight to 6:00 a.m. Temperature sensing circuits are used to shut the HW pump off once the water temperature reaches a pre-set temperature such as 125 F and then starts the pump back up when the water temperature in the pipe drops below a second set point such as 110 F. **Alarm & Safety Controls:** DHW heater is monitored for status and alarm. Alarms shall be generated at host computer (BAS).	
Events	Test pressure, response to varying loads, water temperature and wait time at remote outlets, T&P valve operation, recovery time & temperature, overshoot, heat trap operation, proper drainage, etc.	

Operation Schedule

Record programmed schedule.

	Schedule	Notes
Mon - Fri		
Saturday		
Sunday		
Holiday		

Sensor Location Checks

Check sensor location for proximity to pipe fittings, valves or any other equipment that might effect readings.

Sensor	Actual Location	Notes
Aquastat		
T&P Relief Valve		
Circulating Pump		
Thermometer		
Sacrificial Anode		

Actuator Stroke Checks

Override each actuator from fully closed to fully open. Remove power and note fail position. Note excessive linkage slop and inadequate sealing.

Component	Fully Open	Fully Closed	Fail Position	Notes

Status Check

Override control to each piece of equipment, note response.

Component	Responds?	Notes
Circulating Pump		

Functional Performance Test - Domestic Hot Water System

Equipment Tag: WH-1 & CP-1

#	Simulation Mode/Test	Desired/Expected System Response (check box if observed) ☑	Remark / Other Observed System Responses
1	**Pressure & Temperature Verifications** *Procedure to simulate this mode:* Fill the system with water & document the observations	☐ Verify that system pressure is maintained. Pressure = _____	
		☐ As the water is circulated, confirm that the temperature set point is maintained. Temperature = _____	
		☐ Verify that T&P pop-off valve is safely drained to the nearest floor drain.	
		☐ Verify operation of T&P pop-off valve by lifting a manual release lever.	
		Thermostat operates correctly. (there is a knob that allows you to set the temperature to warm, med or hot) ☐ Verify heater comes on when the tank drops below set point temperature. ☐ Verify the thermostat shuts off the burner when set point temperature is reached.	
2	**System-wide temperature checks.** Verify hot water temperature and wait times for hot water at different locations. Make note in the 'OTHER OBSERVED SYSTEM RESPONSES' column.	☐ Measure temperature at a statistically significant portion of outlets.	
		☐ Make note of any dead spots.	
		☐ Make note of any low-water temperatures.	
		☐ Make note of any long wait times for hot water at remote locations.	
3	**Recovery tests** *Overrides to simulate this mode:* Drain the hot water in order to simulate the maximum, and the resulting temperature recovery.	☐ Measure maximum recovery temp = _____	
		☐ Measure the final recovery temp = _____	
		☐ Verify correct operation of Heat Traps.	
4	**Anti-scalding & temperature control tests** *Overrides to simulate this Test:* Allow the system to return to set point.	☐ Verify the system return to set point with minimal overshoot = _____	
		☐ Verify that overshoot observed is within norm and would not cause scalding.	
		☐ Verify all mixing valves should be confirmed to operate correctly prior to occupancy.	
5	**Hot Water Circulating System Tests (System with hot water return)** Verify the type of HW recirculation control installed and test its components. 1. If the circulator is controlled by timer verify timer settings - ON time vs. OFF time & compare with facility's peak period of HW demand. 2. If the circulator is controlled	☐ Verify that the circulating pump is operational.	
		☐ Set timer to a short OFF period & observe pump stop/start operation.	
		☐ Adjust temp. sensing circuit settings using the aquastatto simulate conditions for pump's ON/OFF operation. Observe temp. values of ON/OFF points. Adjust as needed.	

Functional Performance Test - Domestic Hot Water System

Equipment Tag: WH-2

#	Simulation Mode/Test	Desired/Expected System Response (check box if observed) ☑	Remark / Other Observed System Responses
1	**Pressure & Temperature Verifications** *Procedure to simulate this mode:* Fill the system with water & document the observations	☐ Verify that system pressure is maintained. Pressure = _____ ☐ As the water is circulated, confirm that the temperature set point is maintained. Temperature = _____ ☐ Verify that T&P pop-off valve is safely drained to the nearest floor drain. ☐ Verify operation of T&P pop-off valve by lifting a manual release lever. Thermostat operates correctly. (there is a knob that allows you to set the temperature to warm, med or hot) ☐ Verify heater comes on when the tank drops below set point temperature. ☐ Verify the thermostat shuts off the burner when set point temperature is reached.	
2	**System-wide temperature checks.** Verify hot water temperature and wait times for hot water at different locations. Make note in the 'OTHER OBSERVED SYSTEM RESPONSES' column.	☐ Measure temperature at a statistically significant portion of outlets. ☐ Make note of any dead spots. ☐ Make note of any low-water temperatures. ☐ Make note of any long wait times for hot water at remote locations.	
3	**Recovery tests** *Overrides to simulate this mode:* Drain the hot water in order to simulate the maximum, and the resulting temperature recovery.	☐ Measure maximum recovery temp = _____ ☐ Measure the final recovery temp = _____ ☐ Verify correct operation of Heat Traps.	
4	**Anti-scalding & temperature control tests** *Overrides to simulate this Test:* Allow the system to return to set point.	☐ Verify the system return to set point with minimal overshoot = _____ ☐ Verify that overshoot observed is within norm and would not cause scalding. ☐ Verify all mixing valves should be confirmed to operate correctly prior to occupancy.	
5	**Hot Water Circulating System Tests (System with hot water return)** Verify the type of HW recirculation control installed and test its components. 1. If the circulator is controlled by timer verify timer settings - ON time vs. OFF time & compare with facility's peak period of HW demand. 2. If the circulator is controlled	☐ Verify that the circulating pump is operational. ☐ Set timer to a short OFF period & observe pump stop/start operation. ☐ Adjust temp. sensing circuit settings using the aquastatto simulate conditions for pump's ON/OFF operation. Observe temp. values of ON/OFF points. Adjust as needed.	N/A

11.0 LEED™ Compliance Forms

Requirements for following LEED online template was completed by the AEC engineering staff:

X	EA Prerequisite 1 : Fundamental Commissioning of the Building Systems

(Responsible Individual) (Company Name)

I, DEREK KMICIKIEWICZ, P.E. , from ARCHITECTURAL ENERGY CORPORATION

verify that the information provided below is accurate, to the best of my knowledge.

CREDIT COMPLIANCE

Name of Cx Authority	DEREK KMICIKIEWICZ, P.E.
Name of Company	ARCHITECTURAL ENERGY CORPORATION

Credit Requirements *(check all that apply)*

Completed Owner's Project Requirments (OPR) and Basis of Design (BOD) documentation.	☒
Incorporated Commissioning requirements into construction documents.	☒
Developed and utilized a commissioning plan.	☒
Verified installation and performance of commissioned systems.	☐
Completed Commissioning Report.	☐

NARRATIVE (Required)

Provide a narrative description of the systems that were commissioned and the results of the commissioning process.

AEC commissioned HVAC, lighting and DHW systems. Commissioning activities took place in first half of December 2008. Based on our findings a 'issues log' was created w/ recommendations on how to resolve them. At this point we're still working on a couple of minor issues and will continue to the commissioning within next two weeks.

NARRATIVE (Optional)

Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

The project encountered some difficulties related to HVAC system operation and a number of adjustments had been made. HVAC system is now being monitored and corrections are made daily. Some other field commissioning activities such as lighting control system commissioning could not be completed. CxA will continue after problems are resolved July-August 2009.

☒ The project is seeking point(s) for this credit using an alternate compliance approach. The compliance approach, including references to any applicable Credit Interpretation Rulings is fully documented in the narrative above.

Project Name: Caltrans District 3 Headquarters

Credit: EA Prerequisite 1: Fundamental Commissioning of the Building Energy Systems Points Documented: Y

READY TO SAVE THIS TEMPLATE TO LEED-ONLINE? Please enter your first name, last name and today's date below, followed by your LEED-Online Username and Password associated with the Project listed above to confirm submission of this template.

First Name	Last Name	Date	Username (Email Address)	Password
Derek	Kmicikiewicz	2009-07-09	DEREKK@ARCHENERGY.COM	

SAVE TEMPLATE TO LEED-ONLINE PRINT TEMPLATE

10000409

Letter Template Version A1 .

Appendix D:
Task 6 Report - Plan to Integrate Commissioning into DGS Capital Outlay Projects

Integrating Building Commissioning into State Building Construction

Appendix D: Task 6 Report - Plan to Integrate Commissioning into DGS Capital Outlay Projects

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
August 2009

Arnold Schwarzenegger, *Governor*

CALIFORNIA ENERGY COMMISSION

Prepared By:
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Commission Contract No. 500-04-016

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Prepared For:
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Daryl Mills
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ENERGY EFFICIENCY RESEARCH OFFICE

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Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Melissa Jones
Executive Director

DISCLAIMER

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Integrating Building Commissioning into State Building Construction

Arnold Schwarzenegger
Governor

Plan to Integrate Commissioning into DGS Capital Outlay Projects: Proposed In-House Commissioning Framework

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation

June 2009

CEC 500-04-016

CALIFORNIA ENERGY COMMISSION

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Acknowledgements

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

Plan to Integrate Commissioning into DGS Capital Outlay Projects: Proposed In-House Commissioning Frameworks is an interim report prepared by Architectural Energy Corporation under the Integrating Building Commissioning into State Building Construction Program (contract number 500-04-016) that is managed by Architectural Energy Corporation. The information from this project contributes to PIER's Buildings End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/research or contact the Energy Commission at 916-654-5164.

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Abstract

The goal of the Integrating Building Commissioning into State Building Construction program is to improve the realization and persistence of proper operation and resource efficiency in new State buildings or major renovations, resulting in lower energy use, lower operation and maintenance costs to the State, longer building life, as well as greater worker productivity and user comfort.

This Task 6 Report presents a major revision and expansion of the preliminary plan (Task 4 report) to incorporate an in-house commissioning (Cx) framework for the Real Estate Services Division (RESD within DGS to minimize or supplement the use of third party Cx consultants for DGS capital outlay projects. The effort strives to establish a comprehensive Cx procedural structure based on interviews with DGS staff, direct counsel from the designated Project Advisory Committee (PAC), assessment of the current DGS processes around 3rd part Cx, interviews with commissioning professionals and team members, and "lessons learned" from a pilot Cx study entailing a current DGS building project in Marysville, CA.

1.0 Executive Summary

A comprehensive plan for an in-house Cx (commissioning) framework has been developed for implementation within the Real Estate Services Division (RESD) of the California Department of General Services (DGS). This Task 6 report constitutes a detailed presentation of the proposed Cx framework. It was developed from revisions and expansion of the preliminary plan (Task 4 report), stemming from a final Program Advisory Committee (PAC) meeting that was held at DGS on December 22, 2008, subsequent individual discussions and written communication with PAC members, and final "lessons learned" from the pilot Cx program for the Caltrans building in Marysville, California (Task 5). It does not differ in basic concept from the preliminary plan (Task 4), but is significantly expanded from the original report to incorporate critical additions and recent insights. Vitally, it includes two critical new elements: 1) a transitional, multi-step process that was not included in the preliminary Cx framework (Task 4) for sequentially integrating Cx within DGS over time; and 2) an emphasis on applying the concept of "upstream" quality, introduced by Dr. Edwards Deming in the 1950s for product manufacturing, to building commissioning. The PAC felt the transitional approach would be essential for minimizing or precluding disruptions within current DGS Cx operations. Incorporating Deming's upstream quality aspect for Cx was introduced at the PAC meeting on December 22, 2008 in an overview of the training material being developed for the project, and was met with great enthusiasm.

The Task 2 and Task 3 reports serve to demonstrate the cost-benefit advantage of the proposed DGS in-house Cx framework over the use of 3rd party Cx. The highly informative "lessons learned" in the Task 5 pilot study were invaluable in developing the proposed in-house Cx framework. Though fundamentally in-house, the proposed Cx framework does not exclude 3rd party Cx consultants on DGS projects. Complex buildings and overflow projects that exceed internal DGS bandwidth will continue to be done by 3rd party Cx authorities. 3rd party Cx expertise will also serve to "jump start" the proposed in-house Cx framework and work with DGS in implementing the framework in transitional steps.

The proposed commissioning (Cx) framework establishes DGS as the commissioning authority (CxA) on all capital outlay projects in a team-based structure. While the Project Management Branch (PMB) has authority over a project, including the Cx process, a key aspect of the in-house Cx framework is that the Building and Property Management Branch (BPM) has a lead role both administratively and on-site in the Cx process. To detail the DGS team-based structure, the commissioning authority (CxA) on each capital outlay project is an assigned team, not a single individual, which consists of the project director (PD) from PMB, members from BPM as CxA lead, and members from the Design Services Section (DSS) and Construction Services Section (CSS) in support roles related to design and field testing, respectively. The Green Team serves primarily in a policy-setting role, but engages in some Cx activities directly. BPM is involved from project inception through O&M over the life cycle of the building. Critically, *BPM, in the CxA lead role, orchestrates Cx outcomes with the PMB PD to achieve project quality assurance relative to the owner's project requirements (OPR). That synergy is absolutely crucial to project success and requires a clear understanding of roles and commitment to the Cx process.*

2.0 Introduction

This document presents a multi-step, transitional plan for implementing an in-house Cx (commissioning) framework within the Real Estate Services Division (RESD) of the California Department of General Services (DGS). It is a revision of the Task 4 report (Preliminary plan), based on a final project advisory committee (PAC) meeting that was held at DGS on December 22, 2008, and subsequent one-on-one discussions and written communication with individual PAC members. Also included will be training material and Cx document templates for each phase of commissioning (Task 7). The proposed in-house Cx framework was created in conjunction with DGS.

A critical key in bringing Cx in-house to DGS is to maintain "institutional memory" as personnel get promoted to new positions, retire, or leave employment for other opportunities within or external to DGS. A framework with web-based Cx training material and a database on design, installation, and O&M "gotchas" would serve to minimize degradation of "institutional memory." *For an in-house Cx framework to be embraced and successful, it is essential to show the cost-benefit advantage over the use of 3rd party Cx. The in-house Cx framework also needs to be perceived by all parties as beneficial to their roles and responsibilities and not as an added burden without practical worth.* Additionally, a system of feedback is suggested that signals and acknowledges performance success for all DGS branches and sections involved in a capital outlay project.

It is also important to state that the proposed in-house Cx framework does not exclude 3rd party Cx consultants on DGS projects. Complex buildings like the current central plant project in Sacramento will continue to be done by 3rd party Cx authorities, as will cases when projects become too numerous for the bandwidth of in-house Cx capabilities. Critically, 3rd party Cx expertise will also be utilized to "jump start" the proposed DGS in-house Cx framework and assist in its implementation through transitional steps.

3.0 An In-House Commissioning Framework at DGS

3.1. Overview of the Commissioning (Cx) Process

The building commissioning process requires a commissioning team and a commissioning authority (CxA) that leads, plans, schedules, and coordinates the commissioning team to implement the commissioning process (from ASHRAE Commissioning Process Guideline 0-2005). The commissioning team evolves over time at each building phase (phases and stakeholders shown in Figure 1). As permanent members, it includes the CxA, the owner, and representative occupants. In the early building phases, the Cx team includes the predesign and design professionals, and construction, programming, and project managers. During construction, contractors and subcontractors join the team, while certain members engaged in the early phases will drop out. Facilities personnel (for operation and maintenance) traditionally engage in operating and maintaining the building at initial occupancy, preceded by a few weeks of preparatory training. However, their stakeholder role, though not generally recognized or

budgeted adequately, is actually vital from the very beginning as suggested in Fig. 1. This theme of O&M personnel [which reside in the Building and Property Management Branch (BPM) at DGS) as full stakeholders, starting at a building's planning stage and extending through its complete lifecycle, is emphasized in this report.

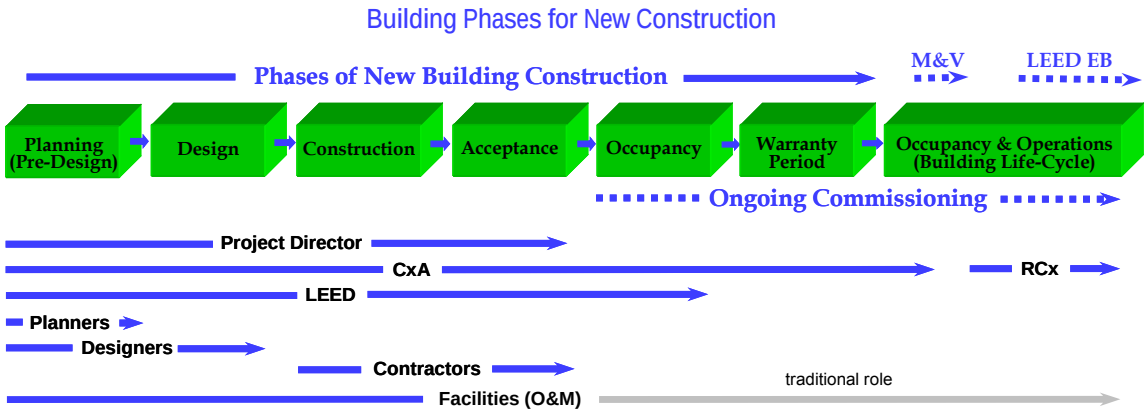

Figure 1: Building phases and stakeholders for new construction, owners are present in all phases.

The role of the CxA is to maintain continuity and flow of the project in ensuring that the owner's project requirements (OPR) are honored and adhered to throughout all building phases from planning and predesign to operation and maintenance (O&M). As such, building commissioning (Cx) is the "glue" that brings continuity and cohesion to the building process. A deeper look at Figure 1 emphasizes the timelines for various participants in the building process, in which Cx and O&M have the longest engagements. However, while all Cx processes may take from one to a few years for a given project, O&M can endure for 30 or more years.

The Task 7 report goes deeper into the Cx process and provides Cx training material for all relevant parties, including DGS, other state agencies, and the California building construction industry as a whole.

3.2. Bringing Deming's Concept of "Upstream" Quality to Building Commissioning

Another theme that will be heavily emphasized in this report in conjunction with building commissioning is the concept and application of "upstream" quality, a notion first introduced to product manufacturing by Dr. Edwards Deming in the 1950s. In essence, the implementation of Deming's ideas conclusively revealed that quality assurance is most critical in the early product phases, such that the later phases are not faced with inefficient and costly "catch up" activities and corrections. Thus, if inspection is the primary filter for product quality, downstream of design and manufacturing, those upstream processes have missed their opportunity for where embodied product quality truly begins and has the most positive impact.

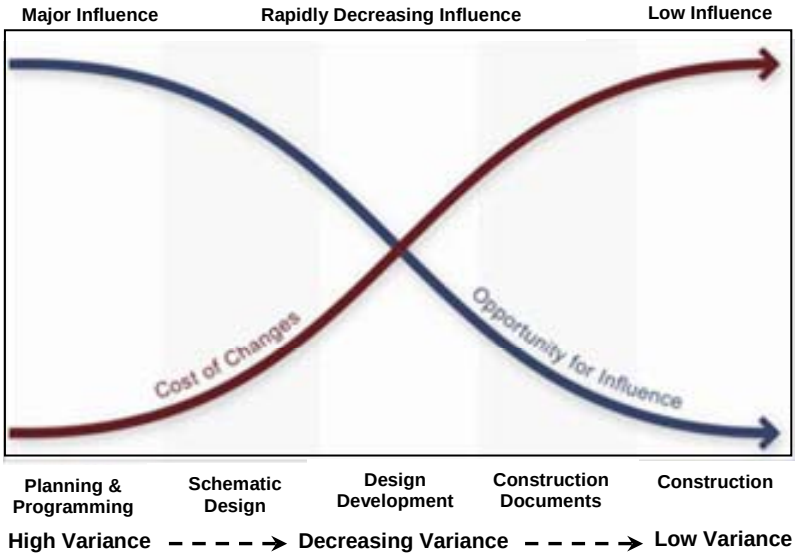

Figure 2: Relative levels of influence and the cost of change at various phases of a building project.

As Figure 2 shows, upstream quality is related to early efforts when influence is greatest and cost of change is lowest. Influence diminishes throughout the sequence of phases, but cost of correction and change increases, as shown. Achieving upstream quality pays huge dividends. Note also that in an effective project, early phases are associated with high variance to maximize influence, whereas later phases require low variance to minimize cost.

Achieving upstream quality clearly maps to the design and construction of buildings, and the role of commissioning is paramount to realizing that goal. Currently, due to its historical beginnings, the profession of commissioning is associated primarily with the functional testing (now referred to as validation testing) of systems that have been designed and installed in a building. This is woeful and is tantamount to the inspection of a product that has already been designed and manufactured, in which the focus on quality is downstream rather than upstream. This needs to change in the commissioning profession, in both perception and reality. Figure 2 captures the essence and merit of "upstream" quality. The proposed in-house Cx framework includes the critical participation of key sections in the Professional Services Branch (PSB), the Design Services Section (DSS) and Construction Services Section (CSS), to help engender upstream quality in capital outlay projects.

3.3. Current Capital Outlay Process for State of California

It is recognized that the current capital outlay process for the State of California does not adequately document, integrate, and track the OPR throughout the design and construction processes and on into facilities management, operation, and maintenance. The purpose of this

project is to remedy this issue through an effective in-house Cx framework in which DGS functions as the CxA on construction projects. In line with DGS' Excellence in Public Buildings Initiative, attending to total building commissioning will be the ultimate goal, which includes all building systems such as electrical, mechanical, lighting, exterior envelop, landscaping, storm water control, plumbing, acoustics, etc. Included with the development of the DGS in-house Cx framework will be a comprehensive training program on commissioning for relevant branches within DGS, and which will also serve other state agencies and outside design and construction communities in California. The training, presented in the Task 7 report, will be suitable for web-based hosting at DGS.

3.4. Need for a Team-Based Commissioning Authority (CxA)

An effective commissioning authority (CxA) has a particularly large role to fulfill. The knowledge, capabilities, and skills of an effective CxA include the following key components:

1. Knowledge and experience in energy system design and function (HVAC).
2. Knowledge and experience in comprehensive sustainable (green) design. Individuals that are LEED AP are highly recommended.
3. Savvy and experience in Cx planning and process management (strong skills in systems thinking).
4. Hands-on field experience with energy systems installation, operation and performance, interaction with other systems, start-up, TAB, functional testing, trouble shooting, and maintenance.
5. Knowledge of building automation control systems (BAS).
6. Ability with the management and transfer of knowledge to relevant parties in the Cx process.
7. Effectiveness in "politically charged" environments.
8. Ability to speak the language of each stakeholder in the vast range of stakeholders involved in all building phases (owners, lessees, planners, architects, engineers, contractors, facilities personnel, etc,), and run effective meetings in a climate of differing perspectives, some of which are at cross purposes.

The last two skill areas, which go beyond the technical and venture into people dynamics, are particularly critical for commissioning success. Given the complexity and required range of skills embodied in the preceding list of criteria, it would be difficult, if not impossible, for any single person to be an effective CxA on a large building project. This would be true also for small projects that are complex in design and function. Thus, it is proposed to establish a team-based Cx framework within DGS that covers the composite CxA criteria. *That is, the requisite CxA knowledge, skills, and abilities would be embodied in a team construct.* A team-based approach is one mode endorsed by ASHRAE for an effective CxA function. To quote from ASHRAE Guideline 0-2005, Informative Annex L, Section 2.3:

> The CxA is a **group of personnel** with expertise and experience in design, construction, and operations of the various systems and assemblies included in

> the project. These personnel are led by an individual who has expertise and experience in successfully implementing the Commissioning Process. (emphasis added)

Notice that it is stated that a single individual should be "in charge" of the team. It would not be leaderless.

Establishing an effective team-based Cx framework within DGS will entail an inter-branch cooperative structure, and the framework should be housed within a specified branch or section. In creating the Cx framework, there is upmost importance in screening and selecting suitable candidates with existing knowledge and capabilities that can be augmented and enhanced through training and a well designed and implemented team construct.

From a logical and practical perspective, the proposed in-house, team-based Cx framework should be housed in the Building and Property Management Branch (BPM), as will be elucidated later, with team support from the Professional Services Branch (PSB), and the DGS Green Team. *In all cases, each branch will continue to serve in its current capacity while also serving in the proposed Cx framework. To be able to handle the extra duties, new personnel would be hired for each branch, as appropriate. Also, it is critical to note that the lead role of the Project Management Branch (PMB) in capital outlay projects is not undermined by the proposed in-house Cx framework.* This point will be elaborated and reinforced later.

In responding to the preliminary plan (Task 4 report), some Program Advisory Committee (PAC) members were concerned, in general, with potential difficulties with developing and implementing an in-house CxA team construct at DGS. This concern can be alleviated through a multi-step, transitional process for incorporating the proposed in-house Cx framework. Additionally, one PAC member felt that a single "super" individual should serve as CxA, not a group led by one individual. A deeper review of the eight points enumerated above of required CxA skills reinforces the formidability of the tasks that would be faced by a single individual as sole CxA. Additionally, Figure 1 emphasizes the wide range of building sequences and stakeholders that a CxA must orchestrate in the Cx process, a tall order for a single person, even a particularly capable one. As we discuss later in this report, one of the lessons learned in the pilot project (Task 5) is that the role of project director (PD) is virtually impossible for even a "super" qualified person, if not aided by a "support and protect the PD" program. *Thus for both a PD and CxA, a team construct is vital for operational success.* However, in both cases a single person remains in charge of the team.

3.5. System of Performance Feedback

In the Task 4 report it was recommended that the proposed Cx framework include a system of merit and feedback, with a possible "score-card" format, that would serve to catalyze responsibility and quality in the upstream building phases. Such a system of enforced accountability is sorely absent in current DGS building projects. The ultimate goal is to ensure quality in all building phases to minimize the inherited "pain" generated in upstream design and construction processes that is felt by O&M personnel (who frequently are BPM personnel, unless a building's O&M resides with non-DGS personnel) and occupants during the life cycle

of a building. At a PAC meeting on December 22, 2008, and subsequent discussions, PAC members reported that a scorecard approach on team performance would not work, based on a prior case that "ran aground" in labor relations at DGS. Only supervisors can evaluate an employee's performance. One PAC member stated that RESD is looking into team level review with the Project Delivery Assessment (PDA) of team performance. It was also felt that providing effective feedback on both good results and bad consequences that are noted or occur long after a project is completed (months or years later) would be exceedingly difficult by virtue of the time lapse.

In response to the preceding comments from the PAC, it was decided to rely in part on what DGS is now pursuing with Project Delivery Assessment (PDA), with some augmentation. *Feedback, without judgment, would be valuable to all involved in a capital outlay project.* That could be provided by BPM personnel serving in a Cx role and subsequent O&M functions. Through use of their software systems (e.g., Maximo) O&M personnel could track issues over time, such as scheduled and unscheduled maintenance items and any significant problems that can be traced back to faulty design or installation not discovered during commissioning. *The idea would be to provide useful information to, and create awareness in, relevant branches or sections both on successes and any downstream problems that emerge over time. In doing so, adjustments then can be made and training programs established for improving all processes upstream to occupancy (i.e., planning, design, construction).*

The recommended system of feedback is to be developed by staff within DGS, consistent with similar internal programs, and will entail coordination with the Project Management Branch (PMB), the Professional Services Branch (PSB), the Building and Property Management Branch (BPM), and potentially the DGS Green Team.

3.6. Range and Application of In-House Cx Framework

The proposed in-house Cx framework will address capital outlay projects that are either design-build or design-bid-build in format. Because small projects (less than 10,000 ft^2 in floor area) tend to receive less attention in the Cx process, yet represent a significant number of construction initiatives -- in fact 77 percent of new construction in the DGS green building program for 2009 is less than 10,000 ft^2 (cited on the DGS web site) -- a scaled down version of the fundamental in-house Cx framework will be implemented to address them. An exception would be small projects that are complex, such as a central plant. Depending on complexity, the full-scale Cx framework would be employed on complex projects, or 3rd party Cx would be utilized. The scaled down version of the Cx framework will differ somewhat from the current *Cx Toolkit for Small Projects* (developed early on in Task 4): http://www.green.ca.gov/CxToolKit. It is important to note that certain Cx activities scale down with reduced building scale, but this does not apply to occupant education which is basically independent of building scale, except for the smallest buildings.

4.0 DGS as Commissioning Authority (CxA)

4.1. DGS Commissioning Framework

The proposed in-house commissioning (Cx) framework establishes DGS as the commissioning authority (CxA) on all capital outlay projects. The branches comprising the proposed Cx Framework include the Project Management Branch (PMB) as ultimate authority over a given project, including the Cx process; the Building and Property Management Branch (BPM) as administrative and operational lead over all Cx activities; the Design Services Section (DSS) and Construction Services Section (CSS) of the Professional Services Branch (PSB) serving in specific Cx support activities; and the Green Team, which serves primarily to set sustainable policy and guide LEED implementation As stated in the Executive Summary (Section 1.0) and Introduction (Section 2.0) of this report, the Project Advisory Committee (PAC) felt that the proposed framework should be implemented in a sequential, transitional manner to preclude counterproductive disruptions in the current DGS Cx processes. The basic proposed framework is presented in this section of the report, with details and transitional steps outlined in various places in Section 5.0, as appropriate, and then summarized in a separate subsection (5.6).

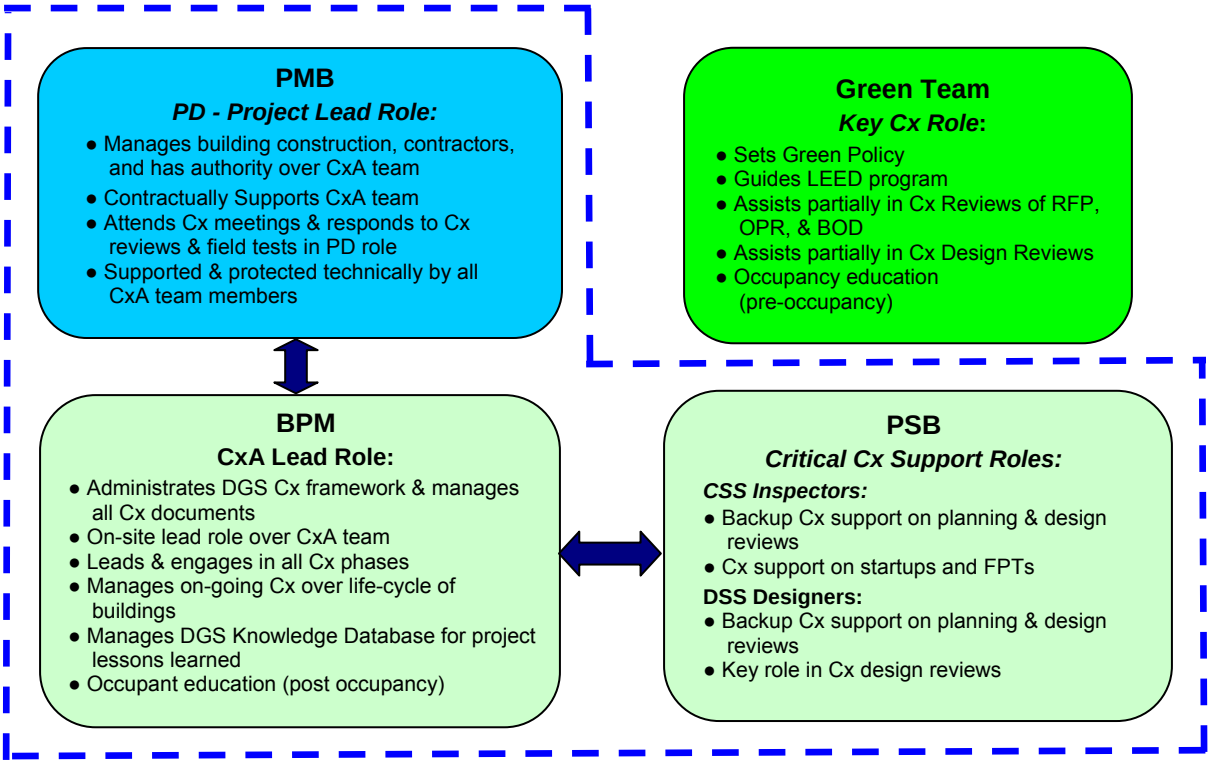

Figure 3: DGS Commissioning Framework.

The commissioning (Cx) framework within DGS is shown in Figure 3. Note the roles and duties for each branch, section, and the special unit (i.e., the Green Team) comprising the in-house Cx framework. *PMB is in charge of the building project and has authority over the Cx process.* BPM serves in the lead CxA role with support from PSB. The Green Team works mainly in a policy

capacity, but also engages in certain Cx activities in order to stay connected to practical matters. *The dotted blue line delineates the working core in the Cx process for each capital outlay project.*

Each branch, section, or special unit serves in a specified role, but the framework is a team-based structure (see Section 3.4) with each team member providing support and assistance to all other members. *A key aspect is that BPM has both lead administrative and on-site operational roles in the Cx process.* The administrative Cx role is for all building projects over entire life-cycles. For each project, a CxA team is formed in which the on-site BPM lead CxA role is specific to the project.

4.2. DGS Cx Team Structure

In the proposed in-house Cx framework, each capital outlay project has a commissioning (Cx) team composed of an outer and inner core as shown in Figure 4. The inner core, as commissioning authority (CxA), orchestrates the entire Cx process on a project.

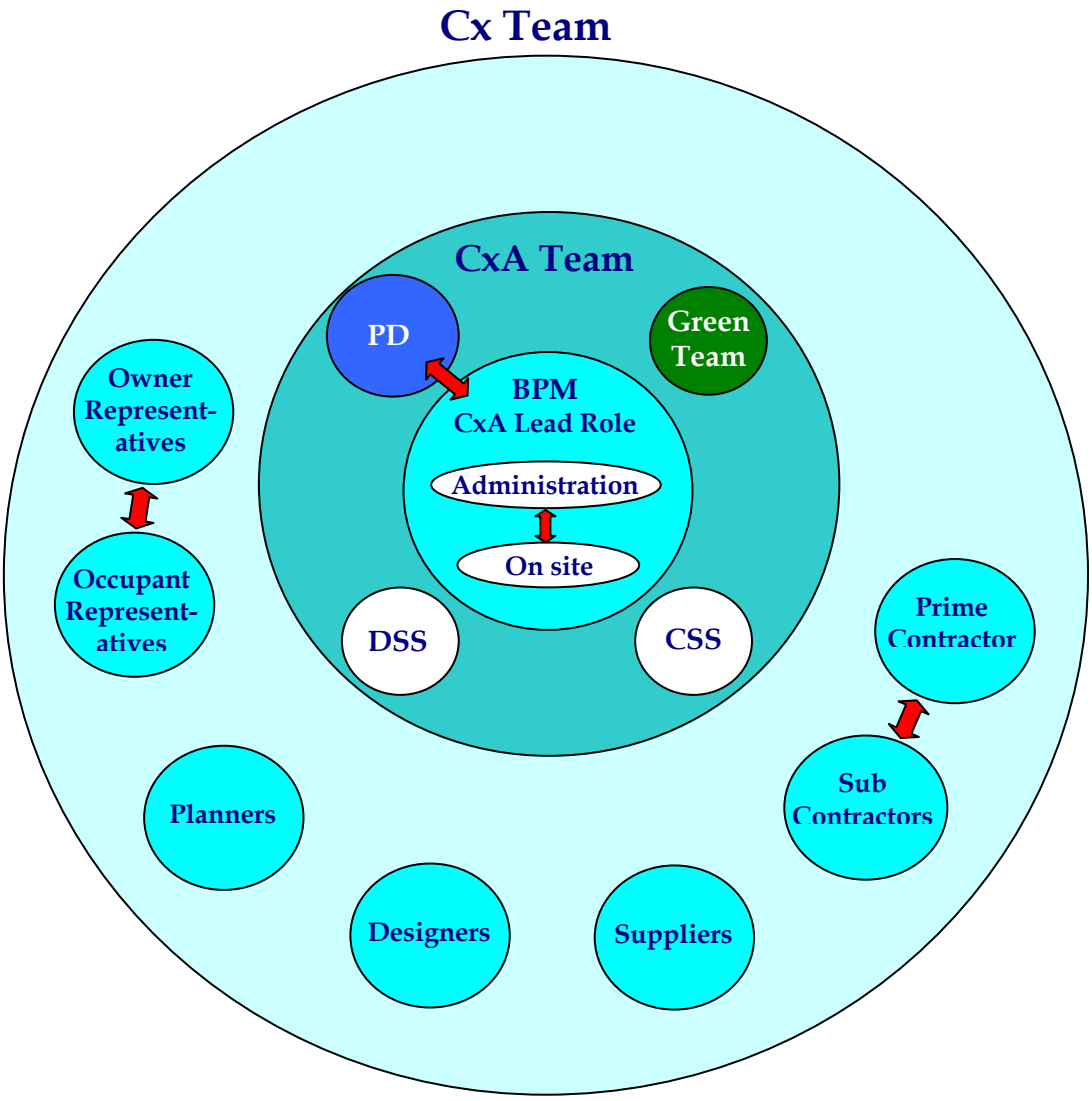

Figure 4: The overall Cx team structure for each capital outlay project.

The inner core is a dedicated DGS team that, in composite, serves as a team-based commissioning authority (CxA) from inception to initial occupancy, through the warranty period, and on through a building's entire life cycle. However, various CxA team members serve for certain time sequences only, as will be illustrated subsequently.

The Cx team members in the outer core (Figure 4) are involved in all Cx meetings and processes, but are distinct from the commissioning authority (CxA) role. The commissioning authority (CxA) on each capital outlay project is an assigned team, not a single individual, that consists of the project director (PD) from PMB as overall project lead, members from BPM as CxA lead, and members from DSS and CSS in support roles (see Section 3.4 regarding the need for a team-based CxA). The Green Team serves primarily in a policy-setting role, but engages directly in some Cx activities on a periodic basis to keep perspectives on Cx details and process flow fresh and connected. BPM is involved from project inception through O&M over the life cycle of the building. *Critically, BPM, in the CxA lead role, orchestrates Cx outcomes with the PD, who has direct authority over the contractor, to achieve project quality assurance relative to the owner's project requirements (OPR). That synergy is absolutely crucial to project success and requires a clear understanding of roles and commitment to the Cx process.*

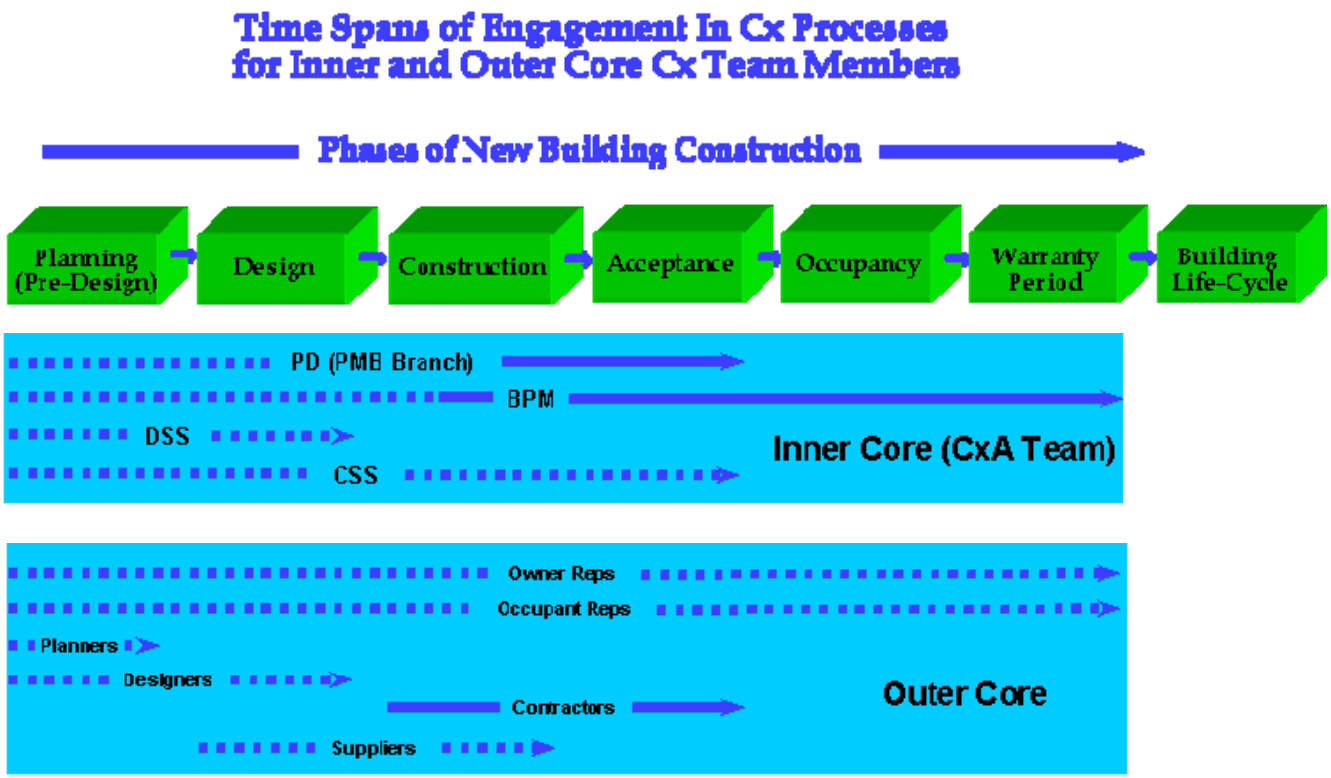

Figure 5: Time spans of engagement in Cx processes of inner and outer core Cx team members for DGS capital outlay projects in proposed in-house Cx framework.

The CxA is the inner core of the total Cx team, which is shown in Figure 4. Dotted lines denote intermittent Cx engagement, whereas solid lines indicate continuous engagement. Engagement of Cx team members in functional roles outside of the Cx process will differ in time span and operational mode.

Time spans of engagement in the Cx processes of the inner and outer core Cx team members in the proposed in-house Cx framework are illustrated in Figure 5, which is a variation of Fig. 1 and is germane to the organizational structure of DGS. Commissioning starts at the planning phases and ends after the warranty period. Note that engagement in Cx may be either intermittent or continuous. Intermittent engagement means the attendance of Cx meetings and the performance of specific Cx activities that are scheduled on a weekly or monthly basis, whereas continuous engagement denotes partaking essentially daily in Cx-related activities. In the inner core CxA team, the PD (from PMB) is engaged in the Cx process from start to initial occupancy, intermittently up until the construction phase starts, and then nearly continuously (with support from a construction management consultant on large projects) until occupancy. The building manager and chief engineer, who are from the BPM Branch, are engaged intermittently in the Cx process until the installation of major systems begins during the construction phase, at which time they become continuously engaged. After Cx, BPM then engages in O&M for the life cycle of the building. The PSB sections DSS and CSS are intermittently engaged in Cx, as shown in the figure. Their roles are to act in a review capacity, which is summarized in Figure 3 and elaborated in Section 5.0 of this report. Note that in all cases the various DGS branches and sections engaged on the CxA team serve in their traditional roles in a capital outlay project, as well.

In the outer core of the Cx team, the owner and occupant representatives are intermittently engaged in Cx meetings and processes from predesign through the warranty period. Project planners and designers are engaged intermittently in the Cx meetings and processes through the planning and design phases, respectively. For design-bid-build projects, contractors are continuously engaged in Cx through the construction and acceptance phases, whereas for design-build projects their continuous engagement in Cx starts during design. Suppliers are intermittently engaged in Cx during the design and construction phases for design-build projects, and for design-bid-build projects they are engaged intermittently during the construction phase only.

A few elaborations on roles and engagement are in order here. Various Cx team members will operate both intermittently and continuously, as the case may be, in their traditional roles outside of their Cx responsibilities during the sequential building phases. It is also worth emphasizing that the essentially continuous engagement in Cx processes by the PD, key on-site BPM personnel, and contractor – starting at construction and continuing until occupancy – is absolutely crucial to actualizing building quality. It is during the daily activities of construction that all of the upstream quality embedded in planning and design is realized through on-site relationship building and continuous attendance to construction and operational details.

Some elaboration is useful regarding the nature and realization of upstream quality (introduced in Section 3.2) relative to Cx processes. Referring to Figure 2, the greatest impact on quality is

made at the planning and earliest design stages. During these stages, the project planners and designers work in an essentially continuous mode over many months to complete their efforts. In contrast, the Cx review process for assuring "upstream" quality entails intermittent engagement by skilled planners and designers on the CxA team who were not involved in the actual planning and design processes. Thus, the Cx review process, which typically occurs in multiple stages, occurs less frequently and for limited time frames compared to the actual planning and design tasks. What this means is that upstream quality assurance, if structured and managed correctly, can be achieved quite economically and not place undue burden on the CxA team members in the Professional Services Branch (PSB) who execute the planning and design reviews. In summary, the crucial upstream review processes of Cx are handled in an intermittent manner, whereas the downstream Cx processes during on-site construction must be addressed more continuously to be effective. That makes the frequent presence of the PD and the daily presence of on-site BPM personnel so indispensable at a construction site for quality assurance.

4.3. Role of BPM in CxA Team: Analogy to Ships

The BPM Building Manager (BM) of a project heads the CxA team, and, in effect, is the captain of the "ship," from start to finish to O&M (the Task 7 report contains training material showing parallels between the commissioning of buildings and ships). In other words, the BM serves to maintain continuity and quality, while attending to the comfort and satisfaction of the occupants over critical and continuous spans of time. As shown in Figure 5, the project director's (PD) job is finished at occupancy. Thus, there is great value in applying the ship captain analogy to buildings. *However, viewing the BM as captain does not subtract from the project director's (PD) authority over a building project, analogous to a ship's captain, who is in charge of managing the crew and operating the ship, but is not the owner and did not manage the design and construction of the vessel.* However, the ship's captain indeed did "oversee" its design, construction, and commissioning, and is responsible for selecting and training the crew. In much the same way, an airline captain is responsible over an airship that he or she did not design or build, and serves in a manner to insure safety, comfort, and efficiency in the operation of the airplane long after the designers, builders, and project manager are out of the picture. Incidentally, a BM and a ship's captain will generally be in command for large spans of time, if not the entire life cycle, but flight crews of a given airplane change routinely.

4.4. Role of BPM in CxA Team: Facilitators and Administrative Support

Depending on project scale, complexity, and scope, the Building Manager may be assisted in leading the CxA team by a facilitator from BPM (as described subsequently) that is experienced in conducting meetings and is knowledgeable in all Cx processes. Also, the CxA team, as "crew," must collectively have critical knowledge, skills, and abilities if the "ship" is to be planned, designed, constructed, operated, and maintained at a high level. The Building Manager receives continuous administrative support in Cx efforts from BPM administrative personnel at DGS headquarters during planning, design, construction, and O&M. Specifically, the office-based administrative role of BPM administrates the overall DGS Cx program and

oversees and manages Cx document generation and archiving for all building phases for each project, including documents generated during on-site inspections and tests as well as in off-site design reviews. The BPM administrative role extends to accessing and contributing to the *DGS Knowledge Database* for lessons learned from the field (described later). The *DGS Knowledge Database* is housed and managed in the Project Management Branch (PMB).

5.0 Detailed Descriptions of DGS Branches Comprising the CxA Role

5.1. Project Director (PD) from the Project Management Branch (PMB)

The PD on a given project has authority and budgetary control during the entire building process from conception to construction to occupancy. *The PD's authority extends to the commissioning team.* Thus, the PD has a unique and critical duel role: 1) To direct the entire construction process of a project, including responding to information generated from the Cx process to correct and improve the project at all building phases; and 2) to ensure that the CxA team has contractual support in dealing with planners, designers, and contractors in running the commissioning process. In turn, the various members of the CxA team "support and protect" the PD in technical and general commissioning matters in dealing with prime contractors, their sub-contractors, and other members of the total commissioning (Cx) team external to the CxA team (see Figure 4). A main concern is exercising proper control and authority over contractors in the Cx process, often a daunting task. Without team support it is difficult, if not impossible, for a PD to deal effectively with the complexity of construction and the agendas of contractors that often work at cross-purposes to the goals of the PD in serving the owner's project requirements (OPR).

It is critical to note that the role of the PD is essentially the same whether the CxA is a 3rd party vendor or an internal CxA team. Thus, there is no fundamental administrative or functional change within PMB in establishing the proposed DGS Cx Framework. *However, for the framework to operate effectively, PDs in PMB need to be trained in and accept their role in the CxA team.* The proposed in-house, team-based framework, if structured properly, can lead to greater continuity and cohesion in the Cx process compared to 3rd party Cx. The web-based training on commissioning being developed for DGS (Task 7) describes the framework in detail and would be useful for all relevant branches, including PMB.

Specific PD CxA roles:

- Has authority over the CxA team and the entire building process.
- Has lead in developing and managing the RFP and the bidding process, which is reviewed by BPM, DSS, CSS, and occasionally by the Green Team.
- Contractually supports BPM in its role in managing the Cx plan and commissioning team.

- Has lead in developing the Owner's Project Requirements (OPR), which is reviewed by BPM, DSS, CSS, and occasionally by the Green Team.
- Engages in review of the Basis of Design (BOD) with DSS, CSS, and BPM.
- Contractually supports review of design submittals with BPM, DSS, CSS, and Green Team.
- Contractually supports DSS, CSS, and BPM in review of design and construction documents.
- The PD manages the design and construction contractors and keeps them on track with BPM's management of the Cx process, using pay applications, as appropriate. This is reinforced by a "*support and protect the PD*" doctrine (see Section 10.0).

PMB critical Cx knowledge summary: The PDs in PMB need to understand and participate in all aspects of the Cx process and be able to take input from the CxA team that is channeled to them by BPM in its CxA lead role. Thus supported, PDs function better in their traditional role and are able to ensure better quality in capital outlay projects.

Multi-Step Transitional Process for Implementing Proposed In-House Cx Framework: Because PMB is already involved with 3rd party Cx, the branch is already knowledgeable and active in the Cx processes. However, as a transitional step, it will be necessary to train PDs within PMB on the proposed in-house Cx framework and get their buy-in to the new internal process. The Green Team needs to coordinate with PMB in the transitional process. In the initial transitional step, PDs will interact on capital outlay projects with 3rd party Cx agents, the Green Team, and on-site BPM personnel, specifically the Building Manager (BM) and Chief Engineer (CE). Immersion of BPM into the Cx process, under PMB management and 3rd party Cx oversight, is critical. Thus, this first step begins the process for BPM to engage directly in Cx activities, both in meetings and in the field, and interact more fully with PDs beyond the traditional roles at DGS. In later transitional steps, PD interactions at Cx meetings will include DSS and CSS personnel. As time progresses, 3rd party Cx agents are weaned from the Cx process as BPM takes over the role as CxA lead working in strong coordination with the PD on each capital outlay project.

5.2. Building and Property Management Branch (BPM)

The proposed DGS Integrated Cx Framework is administratively housed in BPM (see Figure 4), with both office-based and on-site functions. Note the link between office and on-site functions, which is critical for Cx document management and archiving. In its role as CxA lead, BPM will be involved in the Cx process from project inception to operation and maintenance (O&M) throughout a building's life cycle, working with the project director (PD), who has authority over the whole project up to the point of occupancy. Figure 6 shows the details of the BPM structure and roles in leading commissioning (Cx) processes at DGS. T*he Cx administration tracks the commissioning of all capital outlay projects. The on-site CxA crew is specific to a given project.*

Overall Cx program administration will be handled by a single administrator with a small staff of 1-3 administrative assistants and 3-5 facilitators dedicated solely to the Cx program. That is, the Cx administration will comprise a total of 5-9 personnel. Current personnel in BPM can fill

some of these roles, perhaps 2-4, but it is envisioned that 3-5 additional personnel would be hired for the administration of the DGS Cx Framework. *Adding 3-5 new personnel is consistent with the conclusions stated in the Task 2 report for bringing commissioning internal to DGS.* The administrative assistants will manage the flow and archival of Cx documents generated on all projects, including documents generated during on-site inspections and tests as well as in off-site design reviews, and oversee contributions to the *DGS Knowledge Database* on the captured lessons learned in the field by BPM and CSS on design, installation, and operation and maintenance.

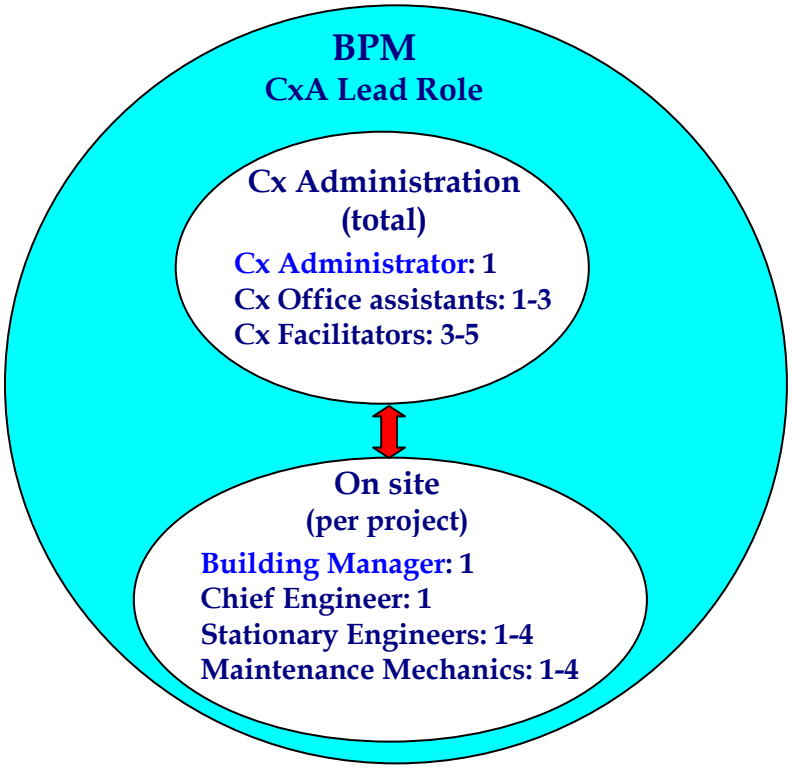

Figure 6: BPM structure and roles.

For each specific project, as needed, a Cx facilitator will assist the Building Manager who heads the CxA team and guides the entire Cx team in executing the Cx process. Facilitators will assist in 1-3 projects at any given time, depending on building complexity and the status of the phases and schedules of the various projects. *The facilitator is knowledgeable in all Cx processes and adept at orchestrating and running meetings. Also, a building manager must possess a critical set of skills and knowledge to be effective in leading the CxA team. Therefore, it is important that BPM structure a duty statement for Building Managers that covers the necessary criteria. The more skilled the Building Manager, the less the need for a facilitator. The most qualified Building Managers can operate without a facilitator.*

On-site BPM personnel are uniquely assigned to a specific project, and serve on the CxA team that performs the Cx tasks on that project, whereas office personnel administratively attend to multiple projects and typically take direct part in fewer Cx meetings and tasks. However, the administrative personnel are regarded as an essential part of the CxA team and their efforts are critical to managing and archiving all Cx documents, including adding to the *DGS Knowledge Database* and informing key CxA team members, especially DSS and CSS, on its evolving contents. Additionally, it is proposed that an automation process be incorporated into Cx tasks in the field and in review meetings to expedite the Cx process and alleviate time consumption in generating and managing essential documents (discussed later in Section 7.0).

The on-site personnel from BPM serving on the CxA team include personnel assigned to a given project at certain sequences in time and do not represent new hires. These include the Building Manager, Chief Engineer, stationary engineers, and maintenance mechanics. However, their roles are extended beyond their traditional roles to include Cx tasks in the field and participation in Cx meetings. This does not add extra burden because these personnel would be present and engaged during these commissioning activities anyway, if performed by a 3rd party.

The Building Manager (BM) and Chief Engineer (CE) should be engaged from the very start of a project (from the planning phase onward) to help develop an effective RFP, and ensure an effective Cx process and proper adherence to the OPR. That is not to say that the BM and CE should be full-time from the very start of the capital outlay process (see Figure 5 and discussion in 4.2). It is recommended that their stakeholder perspectives be captured in standard documents developed by BPM for various types of buildings, but that the BM and CE should be allowed to be present as full stakeholders at key meetings early in the early phases of planning and design. It is recommended that the BM and CE be brought full time into the project when conduit, equipment, and systems are installed in the building. This critically allows them to engage in on-site Cx processes, including pre-functional checks and functional performance testing of systems and controls, and develop beneficial relationships with contractors to help oversee equipment quality, proper installation, and proper access for maintenance and replacement. Stationary engineers and maintenance mechanics assigned to the building should be brought in sometime after the BM and CE, based on building size and complexity. All BPM field personnel serving on the CxA team in a given building project will continue to function in their traditional O&M role in the completed building after occupancy.

In summary, in the proposed Cx framework, a commissioning authority (CxA) team is assigned to each capital outlay project, and the Building Manager assigned to a given project heads the CxA team and leads the entire Cx team under the authority of the project director (PD) (see Figure 3 & Figure 4). As CxA head, the Building Manager is involved in every step of the Cx process from development of the RFP to O&M of the completed building. He or she, with assistance from a Cx facilitator, as may be needed, leads all Cx team meetings, reviews, and field tests, with support from the entire CxA team.

It is critical to note that BPM heads and administrates all Cx activities, but the PD of each project has authority over all building phases for a given project up until occupancy. That is, while the CxA team on

each project "works" for the PD, it has reasonable independence in performing Cx to ensure the integrity of the process.

There are multiple reasons that BPM is best suited to lead Cx efforts:

- BPM operation and maintenance (O&M) personnel, by virtue of continuous hands-on facility experience, have knowledge and insights on what designs and equipment will work well and which will not. This knowledge can be captured in the *DGS Knowledge Database* to inform upstream planning and design processes.
- BPM personnel are knowledgeable on occupant satisfaction over significant periods of time and can evaluate how well an OPR was developed and implemented at all building phases.
- BPM experience and knowledge can be utilized in helping to develop RFPs for bidding; improving the design process; monitoring construction activities, developing relationships with subcontractors and overseeing correct of errors and omissions; developing O&M manuals; and overseeing occupant comfort, education, and satisfaction.
- BPM's continuous presence in the Cx process, particularly its on-site engagement with contractors during construction, will diminish the perception by contractors and their subcontractors that Cx authorities are troublesome external agents to the construction process. Commissioning currently is viewed as adversarial by most parties, particularly contractors, in the construction industry.

BPM O&M personnel with a combination of practical engineering training and field experience enjoy a special perch that endows them with a powerful dual capability: They are: 1) able to effectively operate and maintain a facility, their ostensible role, while also 2) possessing the daily, hands-on experience that can critically inform the design process. Mechanical and electrical design engineers, while highly trained and skilled and possessing important theoretical and practical knowledge, typically have limited or no field experience and are thus removed from the realities of equipment installation, operation, and maintenance. Even engineers with prior hands-on experience in the field become more and more isolated from practical realities as their world centers totally around operating a CAD program at a computer desk. Consequently, their designs can tend to disconnect from what works and what does not work in the field.

Specific BPM CxA roles:

- Works under authority of project director (PD) to lead Cx activities.
- Heads up CxA team, leads commissioning team, and tracks and manages all Cx steps and documents for new and renovated buildings.
- Manages Cx plan and commissioning team with contractual and management support of PD, who has authority over construction contractors.
- Works with PD, DSS, CSS, and Green Team to develop and review RFP and OPR.

- Works with PD, DSS, CSS, and Green Team to review BOD developed by designers. This applies to both design-build and design-bid-build projects.
- Helps review design submittals with PD, DSS, CSS, and Green Team.
- Helps prepare construction checklists with PD and CSS.
- Develops requirements for testing plans and O&M training with PD and CSS.
- Verifies component submittals with DSS and CSS.
- Prepares testing plans with CSS.
- Helps prepare O&M training materials with contractor and reviews material.
- Witnesses start-up and component testing with CSS, develops issues log, and resolves deficiencies with contractual and management support of PD.
- Prepares Cx report.
- Verifies short-term and seasonal trends testing.
- Verifies staff training.
- Resolves warranty issues.

Stakeholder Status: *BPM critically needs to be integrated as a fully vested stakeholder in the capital outlay process.* In analogy to the design, construction, commissioning, and operation of a naval ship, BPM plays a crucial role as a part of the crew of a building, and the Building Manager is, in effect, the captain of the vessel. As such, early and on-going engagement with projects is essential to quality and success. However, the early stages of engagement, up until the installation of the building's conduit and systems, can be limited to key meetings to ensure upstream quality in the building. This allows BPM's role to be economical but effective in the Cx process.

Key function: BPM will contribute critical information to the *DGS Knowledge Data Base* on issues learned in the field on design, installation, and O&M "gotchas" and successes that can serve to improve the planning and design phases of building projects. PMB, DSS, and CSS can all benefit from this application of the *Knowledge Data Base*.

BPM critical Cx knowledge summary: The BPM administration function needs to know all Cx paperwork and processes. The BPM on-site function needs to know all Cx processes as well as its traditional role in understanding building systems and controls and all O&M issues. By their participation in Cx design reviews, in which they share their practical knowledge, BPM field personnel would learn more about design and the design process, which would enhance their role on the CxA team.

Personnel Hiring: It clearly will be necessary to hire an additional 3-5 persons in BPM to serve in administrative roles in the DGS Cx framework. This is consistent with the conclusions of the Task 2 report.

Multi-Step Transitional Process for Implementing Proposed In-House Cx Framework: It is a natural progression to initially insert BPM into the role of team player in the Cx process with 3rd party commissioning agents, and then by steps establish its ultimate lead CxA role in close coordination with the project PD. Thus, at first BPM will serve on planning and design reviews in Cx meetings and also serve on-site during construction with the 3rd party Cx agents. During these early steps toward an in-house Cx capability, BPM personnel will augment their current role in capital outlay projects to forge closer links with the PD, and gain direct experience in Cx under the tutelage of the 3rd party Cx agents. In the process, they will add their knowledge of building system components, understanding of O&M realities that can inform upstream planning and design, and experience with occupant and owner needs, and become comfortable with the Cx process as a whole. A particularly critical element to this transitional process is the establishment of a more connected relationship to PMB and its PDs, with the goal of better quality assurance on capital outlay projects. As time progresses, BPM will coordinate with DSS and CSS as emerging members of the CxA team, while 3rd party Cx is gradually eliminated except for highly complex buildings and overflow projects that exceed DGS bandwidth. Ultimately, the proposed in-house Cx framework will be established with BPM as CxA team lead. The transitional process can be done economically because early-on Cx phases entail intermittent meetings and are consistent with BPM as a full stakeholder in projects. Likewise, on-site Cx activities during construction are consistent with the overall role of BPM as a building is constructed and the Building Manager and Chief Engineer gear up for occupancy and O&M (see Section 4.2 for further elucidation).

5.3. Design Services Section (DSS)

The DSS plays a key role on the CxA team, and is essential in assuring upstream quality at the planning and design phases (see 3.2 on upstream quality). DSS mechanical and electrical designers, by virtue of their engineering design expertise, will be the main reviewers of HVAC systems and controls at the schematic design, design development, and construction document phases for both design-build or design-bid-build designs. Mechanical equipment and controls represent some of the most difficult aspects of design and commissioning.

No potential conflicts arise for design-bid-build projects smaller than 50,000 ft², or for design-build cases, in general. Anyone in DSS could review the design, even if engaged in the design process. In design-bid-build cases over 50,000 ft² for which DSS is involved with the actual design, designers from DSS who were not involved in the design can serve on the CxA team. This is allowable according the LEED-NC Reference Guide:

> For projects larger than 50,000 ft², the individual serving as the CxA on a LEED-NC project shall be independent of the project's design and construction teams. The CxA may be a qualified staff member of the Owner or Owner's consultant to the project, or an employee of one of the firms providing design and/or construction management services. **The CxA shall not, however, have responsibility for design (e.g., engineer-of-record) or for construction.** The CxA shall report results, findings and recommendations directly to the Owner. (*LEED-NC 2.2 Reference Guide*, p.154) [emphasis added].

Specific DSS CxA roles:

- The DSS designers serve in helping to develop and review the RFP and bidding documents, the OPR and BOD. This applies to both D-B and D-B-B projects.
- Help review design submittals: a) schematic design, b) design development, and c) construction documents.
- Help verify component submittals.
- Access *DGS Knowledge Database* to improve design capabilities and review of others' designs. Add to the database on "lessons learned" in design or related matters.

Summary: DSS serves on the CxA team for review of designs done by either DSS personnel or 3rd part designers. All DSS designers are rotated in serving on CxA teams for specific capital outlay projects. In reviewing DSS designs for buildings over 50,000 ft², review is done by DSS personnel not involved with the design. (LEED manuals recognize and endorse this Cx review process as precluding a conflict of interest.). DSS personnel also should make periodic visits to building sites to experience the practical realities of their designs. *Also, by having various DSS personnel serving on CxA review teams, in effect a process of continuing education is enacted* (This implicit educational theme is a key component of the DGS Cx Framework, and is intended to benefit all parties working cooperatively at DGS). As discussed in Section 4.2, the design reviews are done intermittently during the three phases of design and do not entail large increments of time. For example, a 200,000 ft² building of moderate complexity would require 3-5 days of review for each design phase [schematic design (SD), design development (DD), and construction documents (CD)], which is far shorter in time than the design process, itself. Most DGS capital outlay projects are less than 10,000 ft² (77 percent of all projects in 2009 are less than 10,000 ft² according to the DGS website), and would be commissioned through a scaled-down version of the proposed in-house Cx framework (see Section 8.0). For small projects, design review could be done in less than a day for each of the three design phases (SD, DD, and CD).

Personnel Hiring: It will be necessary to hire additional persons in DSS to provide bandwidth to DSS's role in serving on CxA teams. Those people would be additional designers and not be designated as permanent Cx staff, because DSS designers will be rotated into CxA teams over time.

Multi-Step Transitional Process for Implementing Proposed In-House Cx Framework: DSS will be incrementally incorporated into the proposed in-house Cx framework once BPM is fairly well established in the framework and is comfortable with the Cx process as a whole, including the Cx reviews at the planning and design stages. DSS would then be brought into the design reviews and guided by 3rd party Cx agents retained by DGS. This integration process will start with buildings less than 10,000 ft², and then progress to larger scale buildings. For buildings less than 10,000 ft², which do not require LEED documented Cx but which DGS want to run through the Cx process without LEED documentation, a scaled down version of the proposed Cx framework will be utilized. DSS will be trained from the material developed for Task 7, with tutelage from the Green Team, 3rd party Cx agents, and from key personnel from BPM. Once DSS is conversant with small buildings, it will progress to larger scale buildings after some

additional training by the Green Team and BPM, using the training material developed in Task 7. For Cx buildings larger than 10,000 ft², DSS design engineers will work side-by-side with 3rd party Cx agents and BPM to learn necessary skills and procedures, before assuming their full role in the proposed in-house Cx framework.

5.4. Construction Services Section (CSS)

In the proposed in-house Cx framework, CSS inspectors, by virtue of being their field experience, can supplement BPM in bringing a certain reality to the Cx process. By engaging in the Cx framework, CSS (like DSS) also gains a certain continuing education that benefits its traditional role. However, it is important not to saddle CSS inspectors with too many additional duties because they are already spread thin in their traditional role at DGS. It seems that more inspectors need to be hired for traditional roles as well as for serving in the DGS Cx Framework.

CSS inspectors will use the *DGS Knowledge Database* to enhance their own activities, but also add to the database based on their own field experiences.

Note: It has been discussed at DGS that CSS serve as CxA on projects under 10,000 ft², using the *Cx Toolkit for Small Projects* (http://www.green.ca.gov/CxToolKit). However, even though small projects do not get reviewed in the LEED process, they are still required to be stepped through the Cx process at the prerequisite level. The effort and paperwork requirements remain the same as for full LEED certification. It is therefore recommended that the proposed DGS Cx Framework be used in a scaled down version (described in Section 8.0), so that CSS is not unduly shackled with duties that exceed its current bandwidth. The scaled down Cx Framework has the same structure as the full scale version (Figure 3, Figure 4, Figure 5), with the same team members, but fewer personnel are required on the CxA team and fewer Cx steps are undertaken.

Specific CxA roles:

- CSS inspectors serve in helping to develop the RFP and bidding documents, the OPR and BOD, and functional performance testing during construction.
- Help review design submittals.
- Help prepare construction checklists.
- Help develop requirements for testing plans and coordinate O&M training.
- Help verify component submittals.
- Help prepare testing plans.
- Help witness start-up and component testing.

These roles for CSS on the CxA team are not within the current duty statements for CSS inspectors. However, the enhanced roles would add value to the Cx process and would occur intermittently at Cx meetings and not require large amounts of time (Figure 5).

Multi-Step Transitional Process for Implementing Proposed In-House Cx Framework: As with DSS, CSS will be incrementally incorporated into the proposed in-house Cx framework once BPM is established in the framework. CSS will serve in an ancillary role relative to BPM and

CSS and be brought into the various project activities enumerated above under the guidance of BPM and 3rd party Cx agents. Critically, this integration process will start with buildings less than 10,000 ft², and then progress to larger scale buildings. CSS will be trained along with DSS from the material developed for Task 7.

5.5. Green Team

The Green Team serves in the DGS Cx integrated framework in three ways: a) to help establish policy and processes to ensure that sustainability and "greenness" are embodied in all DGS construction projects and the overall DGS Cx framework; b) to help deliver the training on Cx developed in Task 7 on the proposed in-house Cx framework; and b) to serve on the CxA team for certain individual projects to oversee the LEED certification process and support relevant Cx requirements. Thus, while a primary role of the Green Team is establishing policy, it would be critical to have the Green Team involved directly in development of RFPs for projects and in the development and review of the OPR and BOD, and to assist in the review of early design phases once a project is underway. Regular visits to construction sites, perhaps 4-5 visits a year, can keep the Green Team knowledge "real" and practical.

Green Team critical Cx knowledge summary: The Green Team needs to understand the entire Cx process and be experts in LEED to function better in its policy making role. Also, by some level of direct participation in the Cx process for early building phases from planning to design (schematic design and design development), Green Team members are able to lend their knowledge and to keep their policy initiatives honest by their immersion in practical matters.

Multi-Step Transitional Process for Implementing Proposed In-House Cx Framework: The Green Team needs to become conversant in the proposed in-house Cx framework (Tasks 2-6) and the Cx training material developed in Task 7. It needs to participate in the transition from 3rd party Cx to a fully implemented in-house Cx process. Thus, the Green Team will play a role in training BPM, DSS, and CSS. It will be up to DGS to decide which branch will have the lead in overseeing the transition from 3rd party Cx to a full, in-house Cx capability.

5.6. Summary of Multi-Step Transitional Implementation of Proposed In-House Cx Framework

The transitional steps from 3rd party Cx to a full in-house Cx framework were presented in Sections 5.1-5.5 for each relevant DGS branch that will serve within the proposed framework. The transitional process is summarized subsequently. DGS will have to decide which branch will have the lead in overseeing the transition from 3rd party Cx to a full, in-house Cx capability. That role could reside with PMB or BPM, or some combination. The Green Team would be involved, as well.

Project Management Branch (PMB):

PMB is already involved with 3rd party Cx and is knowledgeable and active in the Cx processes from the perspective of management. As a transitional step, PDs within PMB will be trained on the proposed in-house Cx framework, with the goal of achieving appropriate skills for, and buy-in to, the proposed internal Cx framework. The Green Team will coordinate with PMB in

the transitional process. PDs will interact with 3rd party Cx agents, the Green Team, and on-site BPM personnel on Cx procedures on capital outlay projects, specifically the Building Manager (BM) and Chief Engineer (CE). Immersion of BPM into the Cx process, under PMB management and 3rd party Cx oversight, is critical. Thus, as a first step, BPM will engage directly in Cx activities, both in meetings and in the field, and interact more fully with PDs beyond the traditional roles at DGS. In later transitional steps, PD interactions at Cx meetings will include DSS and CSS personnel. In time, 3rd party Cx agents are weaned from the Cx process as BPM takes over the role as CxA lead working in strong coordination with the PD on each capital outlay project.

Building and Property Management Branch (BPM):

To start, BPM fits naturally as a major team player in the current 3rd party Cx process. In subsequent, transitional steps, BPM can be established as the lead CxA role, working in close coordination with the PD on capital outlay projects. Initially, BPM will serve with 3rd party Cx agents in planning and design reviews in Cx meetings and on-site during construction. Over time, BPM personnel will forge closer links with the PD, a crucial aspect of the proposed in-house Cx framework for achieving quality assurance on projects, as they gain direct experience in Cx under the tutelage of 3rd party Cx agents. In turn, they will add their knowledge of building system components, understanding of O&M realities that can inform upstream planning and design, and experience with occupant and owner needs. Further in time, BPM will coordinate with DSS and CSS as emerging members of the CxA team. 3rd party Cx is gradually eliminated except for highly complex buildings and overflow projects that exceed DGS bandwidth. Ultimately, BPM leads Cx on projects. BPM as CxA lead is economically viable because early-on Cx phases entail intermittent meetings that do not consume large amounts of time and are consistent with BPM as a full stakeholder in projects. Likewise, BPM's on-site Cx activities are consistent with the overall benefit of its presence during construction and subsequent preparation for O&M prior to occupancy (see Section 4.2 for further elucidation).

Design Services Section (DSS):

DSS will be incrementally incorporated into the proposed in-house Cx framework once BPM is fairly well established in the framework. DSS will then be brought into design reviews and guided by 3rd party Cx agents. Integrating the framework into DGS will start with buildings less than 10,000 ft², and then progress to larger scale buildings. A scaled down version of the proposed Cx framework will be utilized for buildings less than 10,000 ft², which do not require LEED documented Cx but which DGS want to run through the Cx process without LEED documentation. DSS will be instructed using Task 7 training material, with tutelage from the Green Team, 3rd party Cx agents, and key personnel in BPM. Once DSS is capable of Cx small buildings, it will progress to buildings larger than 10,000 ft², after some additional training. For larger scale buildings, DSS design engineers will work side-by-side with 3rd party Cx agents and BPM to learn necessary skills and procedures, before assuming their full role in the proposed in-house Cx framework.

Construction Services Section (CSS):

CSS will be incrementally incorporated into the proposed in-house Cx framework once BPM is established in the framework. CSS will serve in an ancillary role relative to BPM and CSS and be brought into the various project activities enumerated above under the guidance of BPM and 3rd party Cx agents. Critically, this integration process will start with buildings less than 10,000 ft², and then progress to larger scale buildings. CSS will be trained along with DSS from the material developed for Task 7.

The Green Team:

The Green Team needs to become conversant in the proposed in-house Cx framework (Tasks 2-6) and the Cx training material developed in Task 7. It needs to participate in the transition from 3rd party Cx to a fully implemented in-house Cx process. Thus, the Green Team will play a role in training BPM, DSS, and CSS. It will be up to DGS to decide which branch will have the lead in overseeing the transition from 3rd party Cx to a full, in-house Cx capability. It is recommended that the Project Management Branch (PMB) serve that role.

6.0 Third-Party Cx

6.1. Third-Party Cx Team Members

Third-party Cx consultants are utilized to assist the DGS CxA function on complex buildings beyond the capabilities of the DGS personnel, such as the current central plant project in Sacramento that serves 23 State buildings. These consultants will also serve to assist on educating and qualifying DGS personnel in Cx processes for the transitional steps in establishing the proposed in-house Cx framework. Thus, they will be integral to the in-house Cx Framework from the start to educate DGS personnel and "jump start" the framework. In time, third-party Cx consultants will be transitioned out of the program as DGS becomes conversant in the Cx process. However, third-party commissioning with still occur for highly complex projects. But the plan is for DGS to be better able to manage 3rd party Cx activities by virtue of a maturing process set in motion by the development and implementation of the proposed DGS in-house Cx framework.

6.2. Third-Party Cx versus an Integrated DGS Cx Framework

As discussed in the Task 2 report and elaborated in this report, DGS has the potential, with some development and reframing, to execute its capital outlay projects at a much higher level of quality through team-based orchestration and continuity. In an analogy to shipbuilding and operation (which is outlined in the Task 7 training material and discussed in sections 4.3 and 5.2), a project's building manager and his or her on-site staff, who reside within the Building and Property Management Branch (BPM), serve as the ship's captain and crew to oversee the effective design and construction of a building and to operate it over its life cycle. Thus, the Project Management Branch (PMB) directs the design and construction of the "ship," with critical oversight by the BPM and collaborative support from the Design Services Section (DSS) and Construction Services Section (CSS) to ensure the proper design, construction, and operation of the building. With Cx internal to DGS, it is also possible to develop better and

more connected on-site relationships between BPM and contractors and subcontractors as a continuous, daily link to quality. In summary, an internal DGS Cx framework works more powerfully for continuity, quality, and embedded knowledge compared to 3rd party Cx.

7.0 Automation of Cx Document Generation and Archiving

This section in the preliminary plan (Task 4 report) was slightly revised and expanded, based on PAC meetings in October and December 2008 and subsequent discussions with individual PAC members. Predicated on several discussions with Cx personnel on an industry wide basis and with a large number of building contractors, it is apparent that paper work in the field is considered a tedious drudgery. Thus, it is recommended that DGS evaluate the latest hand-held technology that allows field personnel to easily populate standard Cx forms in the field during tests or in review meetings and transmit them to the central Cx document database in the proposed DGS internal Cx framework. Relevant technologies would include the iPhone or similar devices. A central point is that such technology would reduce both tedium and inputting errors. It is becoming more and more economical and has found common use in many applications. Several members of the Program Advisory Committee (PAC) objected on the incorporation of hand-held devices on the basis of cost and internal DGS policy, but as the cost of such devices comes down dramatically and their powerful impact on process improvement becomes more widely known, it would seem inevitable that they will be included over time. Witness the quick time in returning rental cars, taking inventory in retail stores, and so on.

8.0 Large and Small Projects: Scaling the Cx Framework

The proposed Cx framework will be used in its comprehensive form for medium sized and large-scale projects. The basic Cx Framework is maintained, but scaled down for small projects and requires fewer personnel and steps. For small projects, it is still critical to administrate the Cx process within BPM, as shown in Figure 4 and in Figure 6, but fewer BPM personnel (perhaps only one individual) would be involved with on-site Cx efforts. If DGS is not responsible for operating and maintaining the building, the appropriate facility person would be assigned to serve on-site on the CxA team. PMB would have a PD on the project overseeing the Cx effort, DSS would still be involved in design reviews, and CSS engaged in startup and functional testing activities, as appropriate. It is argued that the existing *Cx Toolkit for Small Projects* (http://www.green.ca.gov/CxToolKit) is not as effective as a scaled down version of the proposed Cx framework for small building projects because it does not include the critical administrative role proposed in this report, and does not link the critical roles of the various DGS branches and sections in assuring project quality.

The DGS Green Team will set policy and procedures for LEED certification of small projects and for "campuses" with several small buildings.

9.0 Value Engineering and the In-House Cx Framework

This section in the preliminary plan (Task 4 report) was slightly revised and expanded, based on PAC meetings in October and December 2008 and subsequent discussions with individual PAC members. It is becoming generally understood that value engineering (VE) frequently does not adhere to its stated purpose in building processes, from design to construction to occupancy. Often the well thought out intents and goals that emerge in planning and early design that would otherwise serve in establishing upstream quality (see Section 3.2 on upstream quality) are filtered out in the VE process to reduce front-end costs or accommodate contractor convenience, resulting in a building that performs poorly over its lifecycle in terms of energy consumption, O&M effectiveness, and occupant comfort and productivity. *Thus, it is critical to include oversight and quality assurance of the VE process as a critical component of the proposed Cx framework.* The Task 3 and Task 5 reports serve to support the need for a better VE process, one that is under the guidance and review of the Cx process.

10.0 Support and Protect the PD Doctrine

Currently on big projects, a PD has assistance from management consultants, but that is seldom sufficient in dealing with construction complexities and orchestrating contractors. Thus, the proposed team-based, in-house Cx framework will embody a doctrine that strives to inform, support, and protect the project director (PD) in construction projects (a sort of "protect and support the PD" program). This enables the PD to better manage contractors and their subcontractors to achieve a better quality building process. In turn, the PD adds clout to the Cx effort, closing the loop on the quality assurance process. The "support and protect the PD" doctrine applies to all buildings (owned or not owned by DGS). The PD should be supported by DSS (on call, as needed, for the duration of a project) on design issues; by CSS (in the field and as needed for duration of project) on inspection and installation issues; and the BPM on practicalities on the building site (on a regular basis, because O&M folks need to follow all phases of construction in preparation for operating and maintaining the finished, occupied building; including input into Maximo of essential O&M issues). The development of a "support and protect the PD" program needs to be done by DGS personnel from relevant branches, given their deeper knowledge of the DGS organizational structure and internal politics. Note: BPM personnel serve O&M only on DGS owned buildings; non-DGS personnel perform O&M on buildings not owned by DGS.

11.0 On-Going (Perpetual) Commissioning

A fault detection and diagnostic (FDD) tool (e.g. Enforma® Building Diagnostics) linked into the building automation system (BAS) is important immediately after functional performance tests (FPTs) and initial occupancy to capture "trends" for better diagnostics and rounding out the Cx process. During the warranty period and then over the entire life cycle of a building, the use of a FDD tool is critical to ensure effective savings through "ongoing" Cx (i.e.,

commissioning continuously). That is, standard commissioning, while crucial to the basic integrity of the design and construction of a building, does not capture important trends over a sufficient time scale to be fully effective, and only deals with the "front end" of a building's entire life cycle. It is only with "ongoing Cx" over the entire life cycle of a building that major savings can be achieved through regular tune-ups, repairs, and replacements. However, the initial Cx of the building ensures an effective design and operational readiness as an effective starting point.

In the near future, FDD tools can also serve to perform the functional testing (now referred to as validation testing) of building systems and controls in lieu of the current on-site testing done by field personnel with CxA oversight. As a consequence, the tedium and logistical limitations of manual functional testing can be eliminated, and greater emphasis can be placed on establishing upstream quality in projects (see Section 3.2 on upstream quality).

12.0 Conclusions

This report describes a preliminary plan to integrate commissioning (Cx) into DGS capital outlay projects in place of solely 3rd party Cx. The preliminary framework (Task 4 report) was reviewed, revised and expanded into a full, detailed version of the proposed in-house Cx framework, based on a final PAC meeting that was held at DGS on December 22, 2008, and subsequent individual discussions and written communication with PAC members. Lessons learned from Task 5, which entailed Cx on a pilot Cx program at the Caltrans building in Marysville, California, have been particularly compelling in key components of the proposed Cx framework, specifically emphasizing the key role to be played by the on-site Building and Property Management (BPM) personnel. The Task 2 and Task 3 reports serve to demonstrate the cost-benefit advantage of the proposed DGS in-house Cx framework over the use of 3rd party Cx. However, the proposed Cx framework does not exclude 3rd party Cx consultants on DGS projects. Complex buildings and overflow projects that exceed internal DGS bandwidth will continue to be done by 3rd party Cx authorities. Because the project advisory committee (PAC) felt that attempting to establish DGS as Cx agent on its capital outlay projects to too quickly would cause major disruption and chaos, 3rd party Cx expertise will serve to "jump start" and provide for the transitional, step-wise development of the proposed in-house Cx framework.

The proposed commissioning (Cx) framework establishes DGS as the commissioning authority (CxA) on all capital outlay projects in a team-based structure. While the Project Management Branch (PMB) has ultimate authority over a project, including the Cx process, a key aspect of the in-house Cx framework is that the Building and Property Management Branch (BPM) has a lead role both administratively and on-site in the Cx process. To detail the DGS team-based structure, the commissioning authority (CxA) on each capital outlay project is an assigned team, not a single individual, which consists of the project director (PD) from PMB, members from BPM as CxA lead, and members from the Design Services Section (DSS) and Construction Services Section (CSS) in support roles related to design and field testing, respectively. The

Green Team serves primarily in a policy-setting role, but engages in some Cx activities directly to maintain perspective and practicality in policy matters. BPM is involved from project inception through O&M over the life cycle of the building. Critically, *BPM, in the CxA lead role, orchestrates Cx outcomes with the PMB PD to achieve project quality assurance relative to the owner's project requirements (OPR). That synergy is absolutely crucial to project success and requires a clear understanding of roles and commitment to the Cx process.*

Appendix E:
Task 7 Report - Communicate Results to State Agencies and to the General Public

Integrating Building Commissioning into State Building Construction

Appendix E: Task 7 Report - Communicate Results to State Agencies and to the General Public

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
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Arnold Schwarzenegger, *Governor*

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Integrating Building Commissioning into State Building Construction

Communication of Results to State Agencies and to the General Public of an Integrated Commissioning Framework for Capital Outlay Projects

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
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Arnold Schwarzenegger, *Governor*

Subtask 7.0 Deliverable

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by binging environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

1. Buildings End-Use Energy Efficiency
2. Energy Innovations Small Grants
3. Energy-Related Environmental Research
4. Energy Systems Integration
5. Environmentally Preferred Advanced Generation
6. Industrial/Agricultural/Water End-Use Energy Efficiency
7. Renewable Energy Technologies
8. Transportation

Communication of Results to State Agencies and to the General Public of an Integrated Commissioning Framework for Capital Outlay Projects is an interim report prepared by Architectural Energy Corporation under the Integrating Building Commissioning into State Building Construction Program (contract number 500-04-016) that is managed by Architectural Energy Corporation. The information from this project contributes to PIER's Buildings End-Use Energy Efficiency Program.

For more information about the PIER Program, please visit the Energy Commission's website at www.energy.ca.gov/pier or contact the Energy Commission at 916-654-5164.

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Appendix A: Introductory Material on Building Commissioning

Appendix B: The Commissioning Process Linked to the Sequential Building Phases of Department of General Services Capital Outlay Projects

Appendix C: Definitions and Narratives of Key Terms in the Commissioning Process

Appendix D: Forms for the Sequential Commissioning Steps in a DGS Capital Outlay Project

Abstract

The goal of the Integrating Building Commissioning into State Building Construction program is to improve the realization and persistence of proper operation and resource efficiency in new State buildings or major renovations, resulting in lower energy use, lower operation and maintenance costs to the State, longer building life, as well as greater worker productivity and user comfort.

This Task 7 Report was developed from the material detailed in the Task 6 report on incorporating an in-house commissioning framework for Department of General Services capital outlay projects. The goal is to provide communication and training on the processes of commissioning on Department of General Services capital outlay projects, but also to inform other state agencies and the general public on the merit and processes of building commissioning. The material is suitable for incorporation into web-based instruction, other electronic educational media, classroom presentation, or a combination of presentational modalities.

1.0 Executive Summary

This document contains training materials for understanding and implementing the commissioning process for new buildings and major renovations. Funded by the California Energy Commission under the Public Interest Energy Research program, the intent is to establish an effective training protocol for integrating commissioning within the State of California's Department of General Services for State buildings. The development of the training material, which was one task (Task 7) of a more comprehensive set of tasks in a comprehensive effort (Tasks 1-7), was strongly informed by a commissioning pilot program (Task 5) entailing the design and construction of a large State office building. The lessons learned from the pilot program were invaluable to the outcome of this overall project and critical to the development of the training material contained in this report. While, the training material is targeted for use as part of a proposed in-house commissioning framework at Department of General Services (Task 6) for its capital outlay projects, the material is also intended for use by other State agencies and for the private construction industry within the state. This goal conforms to the philosophy of the Public Interest Energy Research program as a whole.

The training material is presented in Appendices A, B, C, and D of this report. Appendix A introduces the concept and practice of building commissioning. It is also included in a web-based mockup. The material in Appendix A seeks to impart a basic overview and understanding of commissioning to the intended audience. It sets the stage for subsequent training material presented in Appendix B for the practical implementation of the critical sequences that comprise the commissioning process. Appendix C contains glossary of commissioning terms critical to understanding the material in Appendix B and the process of commissioning in general appears at the end of this report. Appendix D contains sample forms that are essential to the commissioning process described in Appendix B. The contents of Appendices B and C also have been placed in a PowerPoint format that has been distributed to Department of General Services, and will be available to other audiences through the Department of General Services website. Collectively, the material as a whole can be used verbatim in a comprehensive training protocol in the classroom or web-based.

2.0 Introduction

This document contains training material for understanding and implementing the process of building commissioning. It was prepared as part of a project funded by the California Energy Commission under the Public Interest Energy Research (PIER) program. Of particular note, the development of the training material, which was one task (Task 7) of a more comprehensive set of tasks in a comprehensive effort (Tasks 1-7), was strongly informed by a commissioning pilot program (Task 5) entailing the design and construction of a large State office building. The lessons learned from the pilot program were invaluable to the outcome of this project.

The intent of this PIER project is to integrate commissioning within the State of California's Department of General Services (DGS) for State buildings. Therefore, the training material is targeted for use as part of a proposed in-house commissioning framework at DGS. However, in accordance with the philosophy of the PIER program, the material is also intended for use by other State agencies and for the private construction industry within the state.

The training material is presented in Appendices A, B, C, and D. Appendix A introduces the concept and practice of building commissioning. Appendix B contains training material for the practical implementation of the critical sequences that comprise the commissioning process. Although structured around the proposed in-house commissioning framework developed for DGS, the training material of Appendix B is suitable for a more general audience. Appendix C contains glossary of commissioning terms critical to understanding the material in Appendix B and the process of commissioning in general appears at the end of this report. Appendix D contains sample forms that are essential to the commissioning process described in Appendix B.

3.0 Introductory Training Material on Building Commissioning

Introductory training material is presented in Appendix A of this report. It can be used in its entirety as a comprehensive introduction to the concept and practice of building commissioning, and is suitable for web-based training for a broad audience, including Department of General Services, other State agencies, and the general public engaged in building construction. This material seeks to impart a basic overview and understanding of commissioning to the intended audience and set the stage for subsequent training of detailed commissioning processes and procedures. A mock-up website has been established to view the content of this appendix in a web-based training modality.

4.0 Training Material on the Commissioning Sequences in the Context of Building Phases

Appendix B contains training material on the vital sequences that comprise the commissioning process. It can be used verbatim as part of a comprehensive training program for Department of General Services (DGS) in integrating commissioning into its capital outlay projects. As with the introductory training material contained in Appendix A, instruction on the commissioning sequences presented in Appendix A is also intended for use by other state agencies and the general public engaged in building construction. The content of Appendix B also has been placed in a PowerPoint format that has been distributed to DGS, and will be available to other audiences through the DGS website.

The reader is also referred to ASHRAE Guideline 0-2005: *The Commissioning Process* for a more comprehensive treatise on the commissioning process.

5.0 Glossary of Key Terms in the Commissioning Process

A glossary of key terms essential to understanding the commissioning process and enacting the training material presented in Appendix B appears at the end of this report. The reader is also referred to ASHRAE Guideline 0-2005: *The Commissioning Process* for a more comprehensive definition of commissioning terms and concepts.

6.0 Examples of Standard Forms for the Commissioning Process

Appendix C contains examples of standardized forms suitable for use in the commissioning process. They are appropriate for verbatim use or can be modified to better suit the specifics of a given building project. The commissioning sequences detailed in Appendix B are reliant on the forms contained in Appendix D. Along with the training material contained in Appendix A and Appendix B, the forms will be posted appropriately on the Department of General Services website for widespread use.

ASHRAE Guideline 0-2005: *The Commissioning Process* provides detailed explanations of the forms and documents generated in the commissioning process. The interested reader should access this ASHRAE publication to complement the material included in Appendices B-D in this report.

7.0 Summary and Conclusions

The substance of this report, which embodies comprehensive training material on building commissioning, is contained in Appendices A-D. The material will be placed on the Department of General Services (DGS) website and can be used verbatim as part of a commissioning

training protocol. Although designed for use by DGS in a proposed in-house commissioning program for State buildings, the material is suitable for other State agencies, and for a general audience within the construction industry in the State's private sector.

Glossary

Specific terms and acronyms used throughout this work statement are defined as follows:

A&E	Architect & Engineer
AEC	Architectural Energy Corporation
BOD	Basis of Design
CCC	California Commissioning Collaborative
CD	Construction Document
COBCP	Capital Outlay Budget Change Proposal
Cx	Commissioning
CxA	Commissioning Authority
DD	Design Development
DGS	State of California Department of General Services
DOF	Department of Finance
KSA	Knowledge, Skills, and Abilities
O&M	Operations and Maintenance
OPR	Owner's Project Requirements
PAC	Project Advisory Committee
PIER	Public Interest Energy Research
RESD	Real Estate Services Division
RFP	Request for Proposal
RFQ	Request for Quote
SD	Schematic Design

Integrating Building Commissioning into State Building Construction

Appendix A: Introductory Material on Building Commissioning

CONSULTANT REPORT

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Prepared By:
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Arnold Schwarzenegger, *Governor*

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Note: This appendix contains vital introductory material on building commissioning suitable for web-based training for a broad audience, including DGS, other state agencies, and the general public. It can be used as is in its entirety as part of a comprehensive training protocol for DGS, other state agencies, and the general public engaged in building construction. This material seeks to impart a basic overview and understanding of commissioning to the intended audience and set the stage for subsequent training of detailed commissioning processes and procedures. A mock-up website has been established to view the content of this appendix in a web-based training modality.

1.0 Ships and Buildings

1.1. Ships and Buildings: An Introduction

Building commissioning is a quality assurance process inspired by the commissioning of naval warships that can be traced back to 1798 in the U.S. Navy. A ship's commanding officer, as commissioning authority, was responsible for overseeing the design, construction, and outfitting of the ship for its intended purpose, or "design intent." The commander's responsibilities extended to the selection and training of the crew and an extensive "commissioning" process that occurred at sea after christening and launching. In modern times with more complex ships, the commissioning phase at sea can last as long as three years. The crew is fully trained and any equipment flaws and operational errors are corrected prior to the ship being placed into active service, or "commission."

Building commissioning seeks to apply the time-honored principles of naval ship commissioning in achieving quality assurance in the planning, design, construction, and operation and maintenance of buildings of all categories: commercial, industrial, institutional, and residential. Building commissioning can also take lessons from the quality principles introduced by Dr. Edwards Deming in product manufacturing. The goal is to embed quality in all upstream processes, thus minimizing downstream errors and flaws and reducing the role of inspection as the final filter for quality assurance. This "upstream quality" principle will be expanded later in the context of building commissioning.

Summary Points:

- The time-honored principles of naval ship commissioning can be applied to building commissioning (Cx) for quality assurance.
- At issue is quality in planning, design, construction, and operation & maintenance (O&M) of a building.
- Training the "crew" for O&M and tuning the "ship" is also critical with buildings.
- Likewise, the "upstream quality" lessons introduced by Dr. Edwards Deming for product design and manufacture can be applied to building Cx.

1.2. Ships and Buildings: Parallels and Differences

While there are parallels between the commissioning of new warships and buildings, there also are marked differences. Let's consider ships versus commercial and institutional buildings. A naval ship is an instrument for achieving effective warfare. Prior to launch, the captain oversees the planning, design, and construction of the ship, by a crew separate from the crew that goes to sea. After launch, the captain and sea crew operate and maintain the vessel for its intended purpose, after an intensive period of preparatory training. If the ship was poorly designed and constructed, or the crew insufficiently trained, the consequences can be dire.

A commercial or institutional building, on the other hand, is an instrument for achieving occupant comfort and productivity, and can be viewed as somewhat similar to a passenger ship. As such, the occupants of such buildings typically are not the building's operating "crew." Their "commander," the CEO or boss, typically is not responsible for overseeing the building's design, construction, operation and maintenance. Indeed the occupants within a building are engaged in activities that are to various degrees coherent and interdependent like a crew or team, and the building is designed, or should be, to accommodate those activities. However, an operating crew quite separate from the functions and concerns of the occupants actually runs and maintains the building (certain industrial buildings may be the exception). Furthermore, unlike a naval ship, occupancy and full operation occur without an extended commissioning phase "at sea," although the operation and maintenance, or O&M, "crew" is rigorously trained in the months prior to occupancy. Finally, short-term and seasonal performance trends of the building's systems are evaluated by the O&M team and commissioning authority within the first year of occupancy to enable a final operational "tune up" and to attend to any warranty issues. This final step marks the end of the formal commissioning process for a new building.

Unlike a ship, however, faulty design and construction of a building due to poor or nonexistent commissioning typically would not lead to catastrophe. However, occupant safety, comfort and productivity can be compromised, and O&M costs can become exorbitant. Thus, the role of building commissioning is not to be minimized or dismissed, and the analogy with ship commissioning is valid.

Summary Points:

- A naval ship is an instrument of warfare.
- A warship's occupants are the crew that trains at sea and operates it after Cx.
- Lack of commissioning can be disastrous or fatal.
- A building, like a passenger ship, is an instrument for occupant comfort and productivity.
- A building's occupants are not its crew, and are not trained to operate it. A separate O&M crew is trained to run and maintain the building.
- Lack of commissioning of a building, while perhaps not fatal, can compromise occupant comfort, productivity, and safety. And O&M costs can become exorbitant.

2.0 Central Role of Commissioning: A Crucial Emphasis

The central role of building commissioning is to honor and serve the owner's project requirements, or OPR, formerly referred to as the "design intent." The OPR embodies the purpose and intent of a building from the perspective of the building owner, the occupants who will function within it, and the team that will operate and maintain it. The commissioning process ensures quality in adherence to the OPR by forming and orchestrating a commissioning team, led by a commissioning authority, and undertaking a series of defined steps (outlined later) that serve at all building phases to minimize errors, disruptions, loss of continuity, and gaps in responsibility.

Summary Points:

- Honoring the owner's project requirements (OPR) is the paramount concern.
- Consideration for the owner, occupants, and O&M crew effectiveness drives the Cx process.
- A well orchestrated Cx effort can minimize errors, disruptions, and expense.

2.1. The Building "Crew"

Let's take a deeper look at a building's crew. In a clear departure from a ship's crew, which consists of its captain, officers, and sailors, the "crew" of a building can be broadly defined to include the architects and engineers responsible for its design, the contractors that construct it, and the personnel that operate and maintain it over its life cycle. By so integrating the building's "crew", the potential for fragmentation of responsibilities and outcomes can be minimized, provided an effective team framework is put in place, a key point elaborated later. At heart, as previously stated about the central role of commissioning, the crew's concerns should always lie with the building's occupants, starting with the planning, design, and construction phases long before occupancy. This is a crucial point that drives the commissioning process. Various members of the crew join or drop out at various phases in the building sequence (described later). For example, the planners, designers, and contractors drop out in sequence at various stages before occupancy. Thus, unless counter measures are taken, there is strong potential for loss of continuity and multiple opportunities for errors and flaws to occur that undermine the building process and consideration for occupants. By the time the final remnant of the original crew remains to operate and maintain the building (the O&M crew, or team), there frequently are defects in design, equipment function, and operational procedures that degrade the efficiency of the building and compromise the comfort and performance of the occupants. That is, both the occupants and O&M crew can inherit problems that were generated in the upstream building sequences and not caught and corrected. This is both costly and disruptive. Proper commissioning and a well integrated building "crew" can minimize or prevent these issues.

Summary Points:

- A ship's crew versus its planners, designers, and contractors are separate teams.
- For buildings, it is useful to include all stakeholders (planners, designers, contractors, owner, occupants, and O&M personnel) as an integrated crew, or team.
- Such team integration leads to a better Cx process and results in greater building quality, utilizing the "upstream" quality principle.
- After occupancy, most initial crew members drop off and the O&M personnel are the remaining "crew" throughout the building's life cycle.

2.2. The Commissioning Team and Commissioning Authority

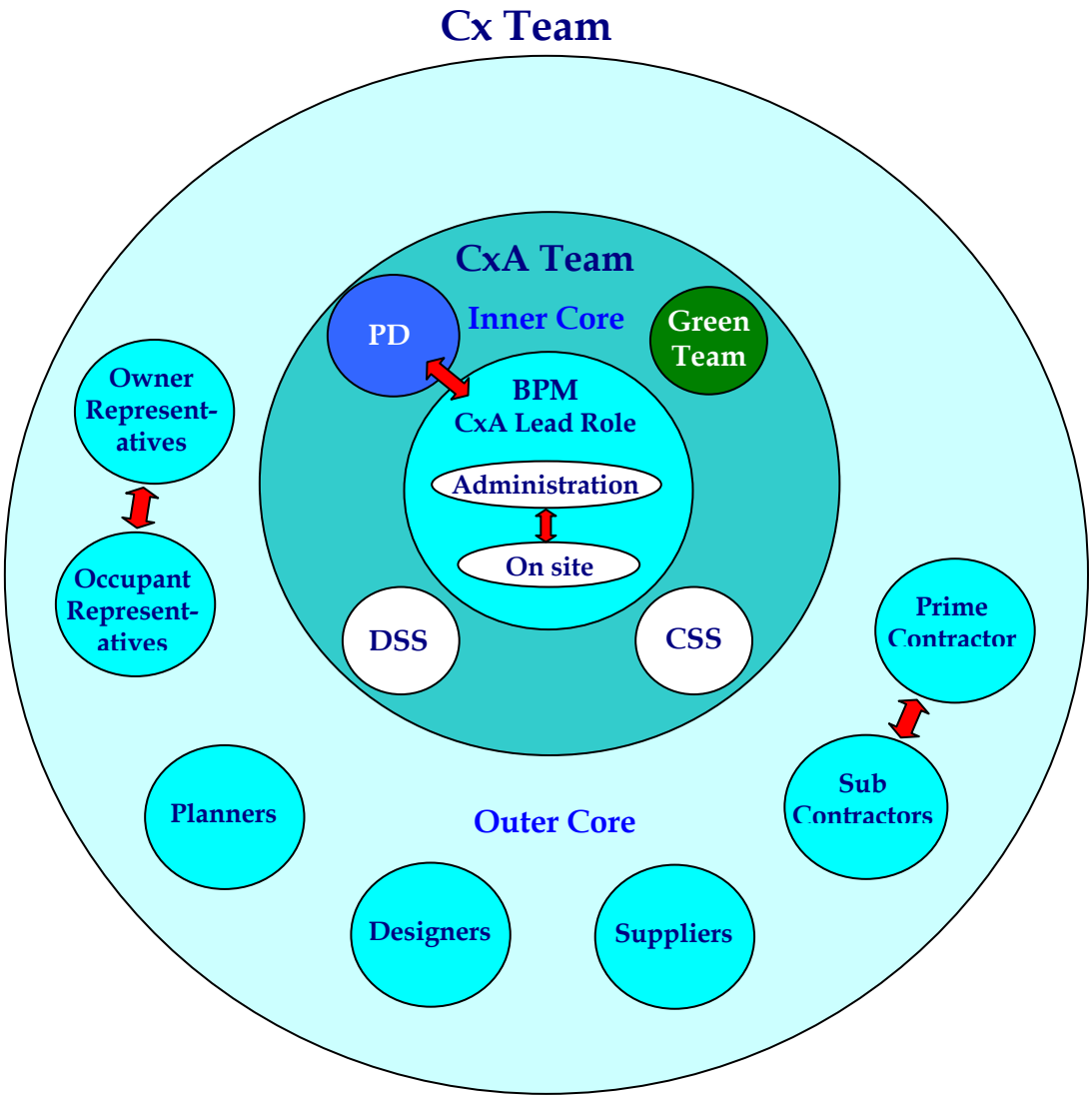

Figure A-1: A schematic of the commissioning (Cx) team and the commissioning authority (CxA). Size of the Cx team and CxA depends on building size and complexity. The project director (PD)

has authority over the construction process and Cx team, and is supported and protected by the CxA in dealing with contractors and quality issues.

The commissioning team consists of key members from the various disciplines responsible for the planning, design, construction, and operation and maintenance of a building. It also includes the building owner and representative occupants. The commissioning team is led by a commissioning authority, a subset of the commissioning team consisting of several individuals. *However, one person is in charge of the commissioning authority, playing the role of "captain" of the building.* Also, the CxA role must be free of conflicts of interest, as will be elucidated later. Fig. A-1 depicts the commissioning team and commissioning authority. The size of the commissioning team and commissioning authority scales with the size and complexity of the building being commissioned. We will explore the structure and formation of both the commissioning team and commissioning authority in greater detail later.

Summary Points:

- The commissioning team includes a smaller team, or individual, that serves as commissioning authority (CxA) to lead the commissioning (Cx) effort.
- The size of the Cx team and CxA team scales with building size and complexity.
- A single individual is in charge of the CxA team.

2.3. On-Going (Perpetual) Commissioning

After commissioning of a newly constructed or renovated building it is critical to perform on-going commissioning, or regular tune ups, over a building's life cycle to realize full operational efficiency (discussed later). This is accepted practice with ships, but is done far less frequently with buildings. On-going, or perpetual, commissioning is best accomplished by integrating diagnostic software into the building's automation system (BAS) to continuously inform the O&M team about emerging problems.

Summary Points:

- Initial commissioning is important, but must be followed up with on-going (perpetual) Cx over the life cycle of a building to realize the lion's share of all potential savings.

3.0 Building Commissioning and Quality Programs in Product Manufacturing: Embedding Upstream Quality

3.1. Introduction to Product Quality in Design and Manufacture

Going beyond ship commissioning, an investigation of quality programs in product manufacturing provides useful guidance in developing an effective building commissioning framework. The pioneering work of Dr. Edwards Deming led to the advent of six-sigma quality

programs in Japanese and American manufacturing. The core principle is to incorporate quality in all design and manufacturing sequences by reducing unwanted process variance. However, a point frequently missed is that variance is necessarily greater and desired, but still controlled and constrained, during the iterative steps of design where investigation and creativity are essential. (This fully applies to building planning and design, as well.) During product manufacture, though, variance is minimized as much as possible when "getting it right the first time" is the order of the day. Implementing the principle of embedded upstream quality minimizes or eliminates the reliance on inspection to ensure the quality of completed products. Quality becomes inherent, at the proper level of variance, in all upstream processes such as product design; the design and implementation of manufacturing equipment, systems, and processes; and the training of assembly line personnel. Inspection is only included as the last filter, with far less emphasis and dedicated resources.

3.2. Upstream Quality in Buildings

Building commissioning should strive to apply this upstream quality principle, as well, and not overly rely on downstream inspections. Regretfully, this goal is frequently not fully achieved. Consequently, omissions and deficiencies in upstream sequences are often felt at later building phases, particularly during O&M, and can be hard to fix. Examples include excessive failure rates during functional testing of systems, poor access to controls and equipment for maintenance and replacement, and occupant thermal discomfort due to poorly designed or installed HVAC systems. In fairness, it is typically much harder to achieve upstream quality in building construction than it is in product manufacturing, for a number of reasons. Product manufacturing is an inherently more controlled process performed in a central facility. It is generally not at the mercy of inclement weather, and does not have the scheduling and coordination issues associated with mechanical, electrical, controls, and plumbing contractors. (Interestingly, though, ship building has some parallels to building construction in this regard.). However, a well structured commissioning team with an effectively written commissioning plan can maximize quality in upstream and all subsequent phases and catalyze the construction of an excellent building that is faithful to the OPR, with only routine O&M issues. Figure A-2 elucidates the levels of influence, variance, and costs of change through the progression on a building project.

Summary Points:

- Quality is related to minimizing unwanted process variance.
- Quality should be embedded in all upstream processes to minimize or preclude downstream problems.
- Frequently misunderstood is that design requires some variance for creativity and success, whereas the construction process should entail minimum variance to minimize the cost of late changes.
- Inspection is the filter of last resort for both product manufacture and building construction, and is a sign of errors or poor decisions generated upstream.

- Thus, errors found in functional performance testing reflect mistakes in equipment design or installation.

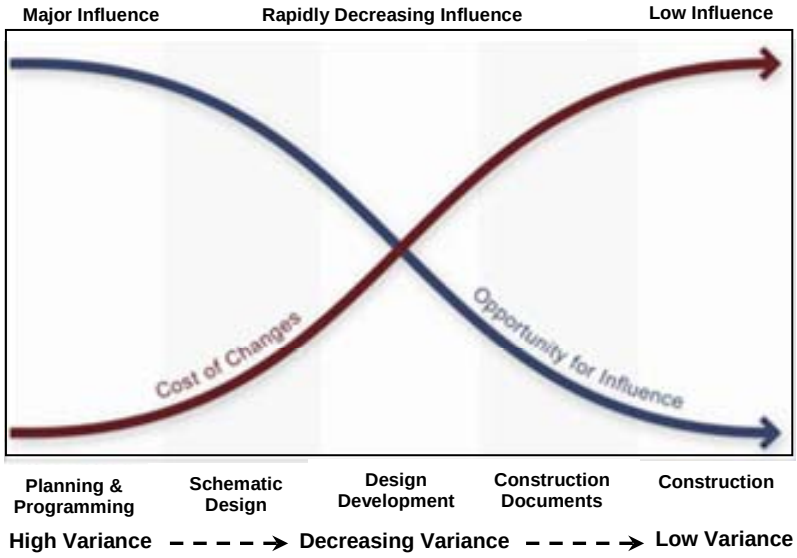

Figure A-2: Relative levels of influence and cost of change at various phases of a building project. Early on, influence is greatest and variance is highest, but both diminish throughout the sequence of phases, as shown. Achieving upstream quality pays huge dividends.

Integrating Building Commissioning into State Building Construction

Appendix B: The Commissioning Process Linked to the Sequential Building Phases of Department of General Services Capital Outlay Projects

CONSULTANT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Architectural Energy Corporation
Contract #500-04-016
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Arnold Schwarzenegger, *Governor*

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Note: This appendix contains training material on detailed building commissioning processes and procedures. It can be used verbatim as part of a comprehensive training program for the California Department of General Services (DGS) in integrating commissioning into its capital outlay projects. The material is also intended for use by other state agencies and the general public engaged in building construction. The content that follows also has been placed in a PowerPoint format that has been distributed to DGS, and will be available to other audiences.

1.0 A Birdseye View of the Building Phases for New Construction and Stakeholder Timelines of Engagement

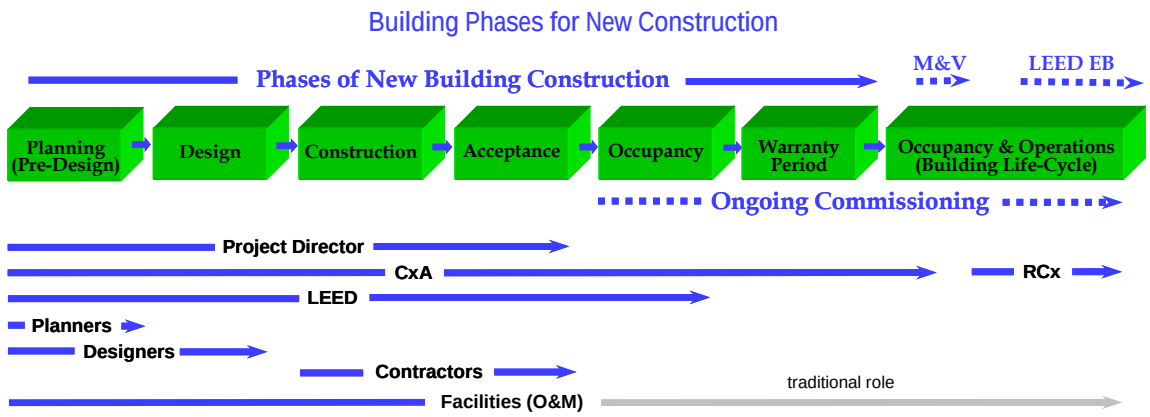


Figure B-1: The building phases for new construction and the sequences and timelines of stakeholder engagement. Owner and occupant representatives are involved at all phases.

- The role of commissioning is to provide the continuity and "glue" for all building phases to achieve quality assurance
- Planning and design can take months or years depending on building complexity and scale
- Construction can take months or a few years, depending on scale and complexity
- A building lifecycle can be 30-50 years, during which time renovations will occur periodically (i.e. recommissioning, RCx)
- Note the time span of engagement for various stakeholders, hence their implied "stake"
- Owners and occupant representatives are engaged at all phases
- Traditionally O&M personnel initially engage at occupancy, but should be allowed to engage earlier in a lead commissioning authority (CxA) role to ensure upstream and downstream quality assurance
- Note that the project director (PD) drops out of the picture at initial occupancy, and O&M personnel take over for the life cycle of the building

2.0 Establishing Upstream Quality

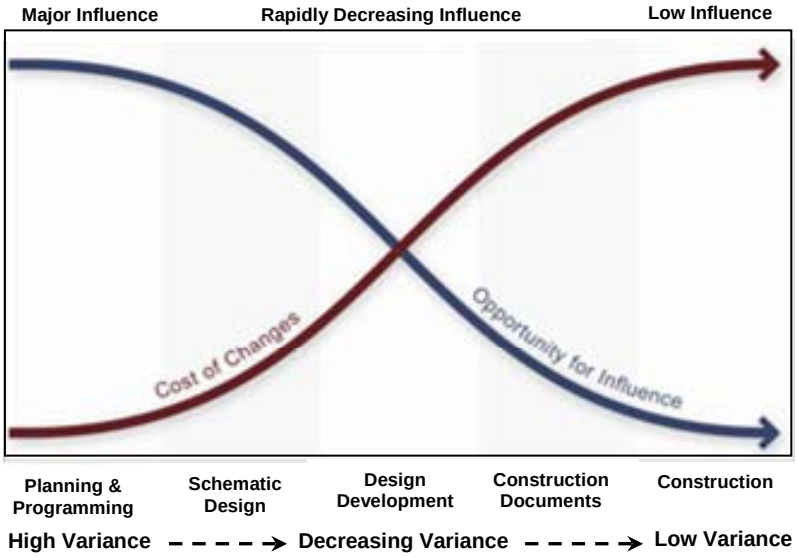


Figure B-2: Achieving upstream quality pays huge dividends, so earliest Cx activities are the most critical.

- Critical attention to stakeholder roles, activities, and interactions in the early building phases is essential to achieving upstream quality
- Upstream quality leads to overall quality assurance with minimal problems, fewer call backs, and far less occupant discomfort and inconvenience
- Downstream inspection and remediation is a poor, costly filter for quality
- Stakeholder mindset with guidance from the commissioning authority (CxA) team serves to set everyone's sights on upstream awareness

3.0 Commissioning Sequences Linked to Building Phases: An Overview

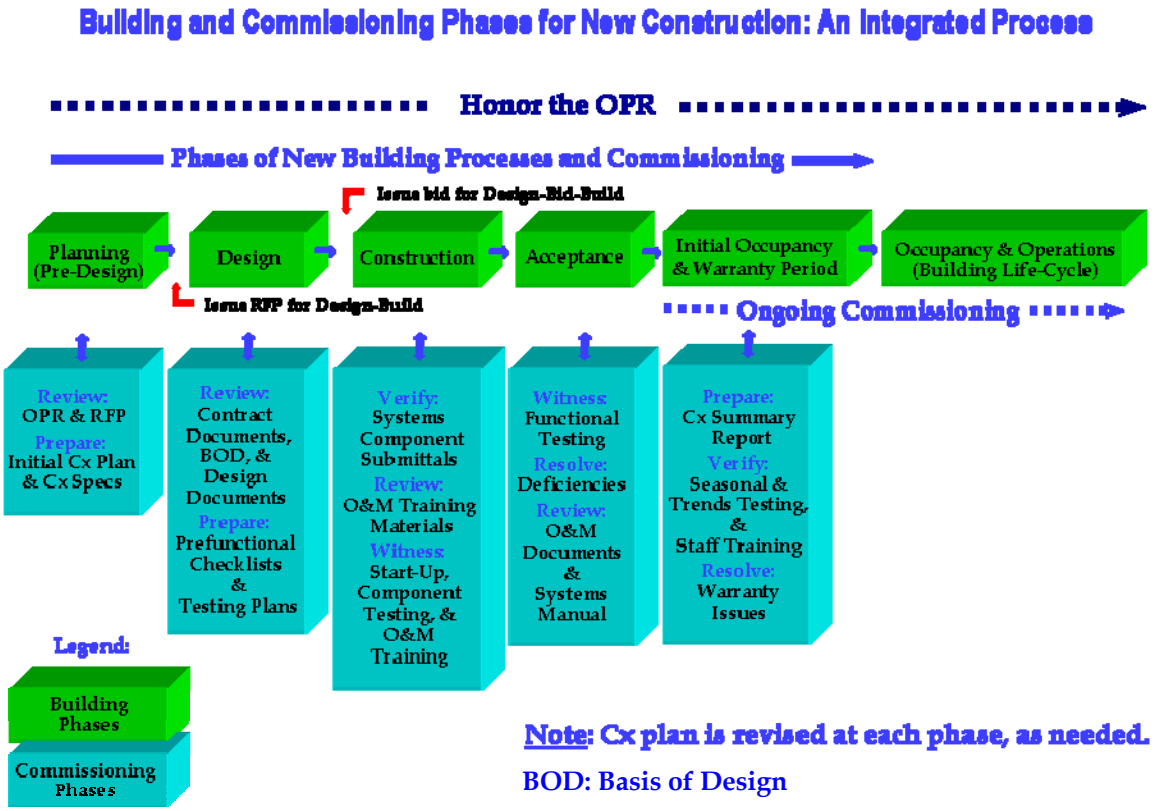


Figure B-3: Commissioning sequences in support of the building phases for new construction.

- Figure above presents an overview of the commissioning (Cx) process
- Details are presented subsequently for each Cx sequence, and a glossary of terms is included in the training materials
- Owner's project requirements (OPR) hover over each capital outlay project to bring continuous focus and emphasis to the purpose and goals of a new building or major renovation
- Commissioning (Cx) attends to emphasizing and honoring the OPR and its quality assurance at all phases
- Note specific Cx activities at each building phase (more details and explanations provided later)
- Size of Cx team and scale and scope of Cx activities depend on scale and complexity of capital outlay project
- Regular meetings are scheduled to orchestrate Cx team members and all Cx activities
- Note distinction between Design-Build versus Design-Bid-Build projects

- Ongoing (perpetual) Cx starts at initial occupancy and continues through building's lifecycle to ensure building stays "tuned"
- Cx plan may be revised throughout the building phases as need for plan refinement emerges, or new requirements and discoveries arise, but tends to be revised far less in downstream phases as changes become more costly and counterproductive

4.0 The Commissioning Team: Inner and Outer Cores

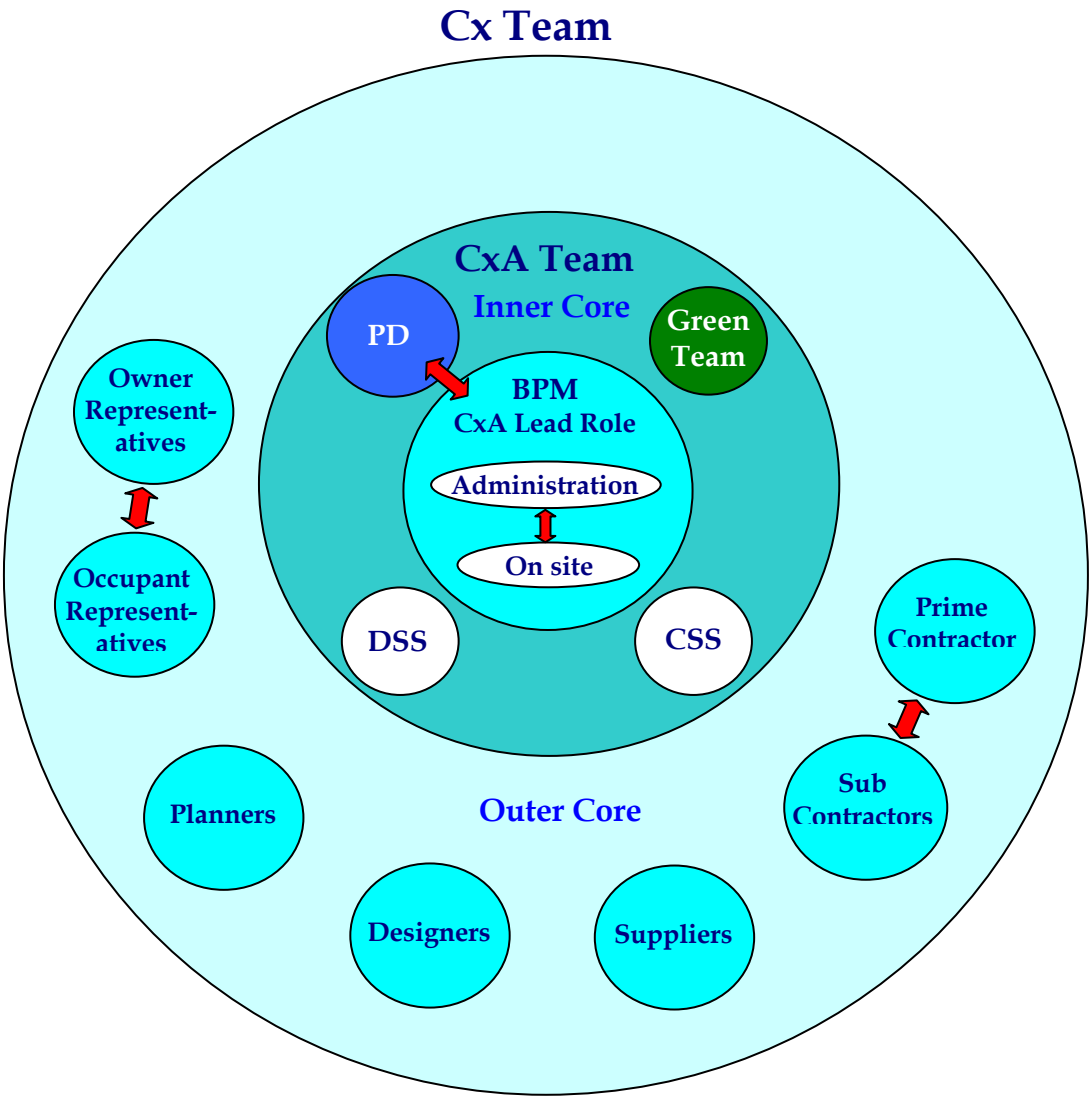


Figure B-4: Cx team and CxA team.

- Figure is geared to commissioning framework within the DGS organizational structure, but can be readily generalized to other organizations and settings
- Inner core of commissioning (Cx) team is commissioning authority (CxA) team that oversees and guides the commissioning process
- Outer core of Cx team consists of the professionals, practitioners, and trades people engaged in the planning, design, and construction of a building
- Owner and occupant representatives strongly linked to CxA team in interest of honoring project's OPR (owners project requirements)
- Project Director (PD) has authority over entire project, including commissioning process

- Commissioning team led by a commissioning authority (CxA), which itself is team-based
- A single person is in charge of the CxA team to maintain team cohesion and effectiveness
- Building and Property Management Branch (BPM) leads CxA team under authority of the PD
- BPM has lead CxA roles on-site (project specific) and in centralized administration (all projects)
- Close cooperation of PMB and BPM is crucial to Cx process , hence ultimate success of capital outlay project
- DGS Green Team plays critical policy role as part of DGS Cx framework for all capital outlay projects
- Design Services Section (DSS) plays major role in review of design phases as part of CxA team
- Construction Services Section (CSS) plays support role at various early phases, construction phase, and acceptance phase as part of CxA team

5.0 Overview of Commissioning Team Timelines and Levels of Effort

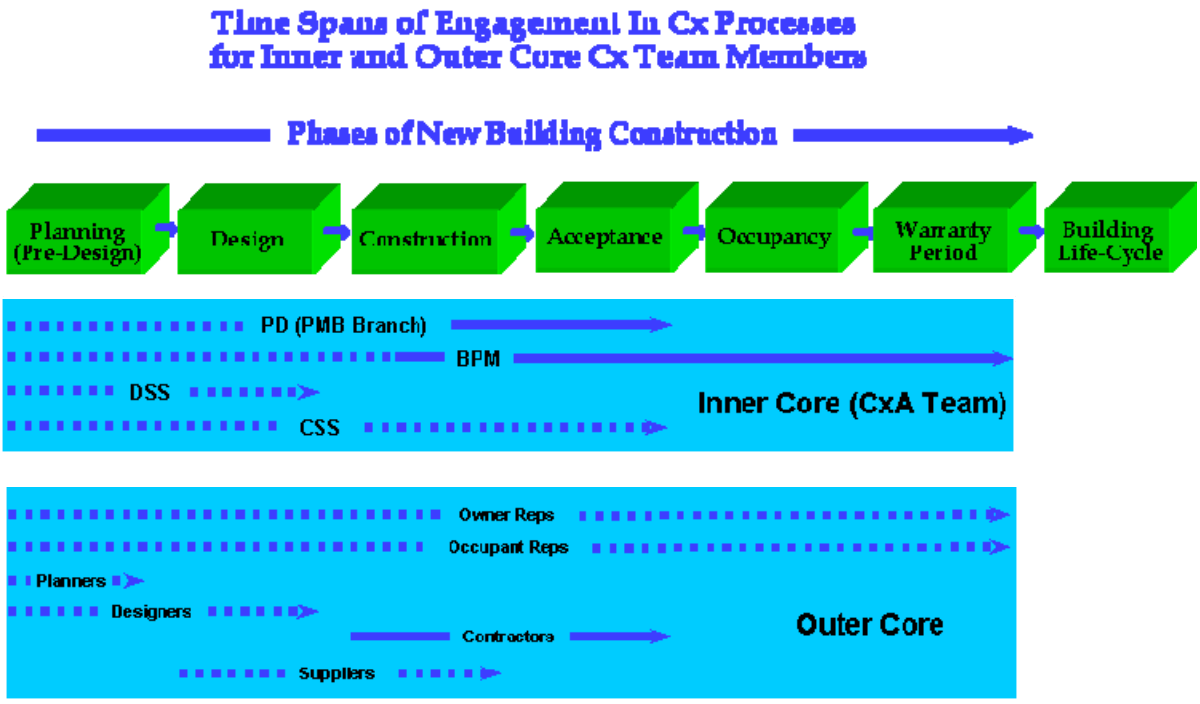
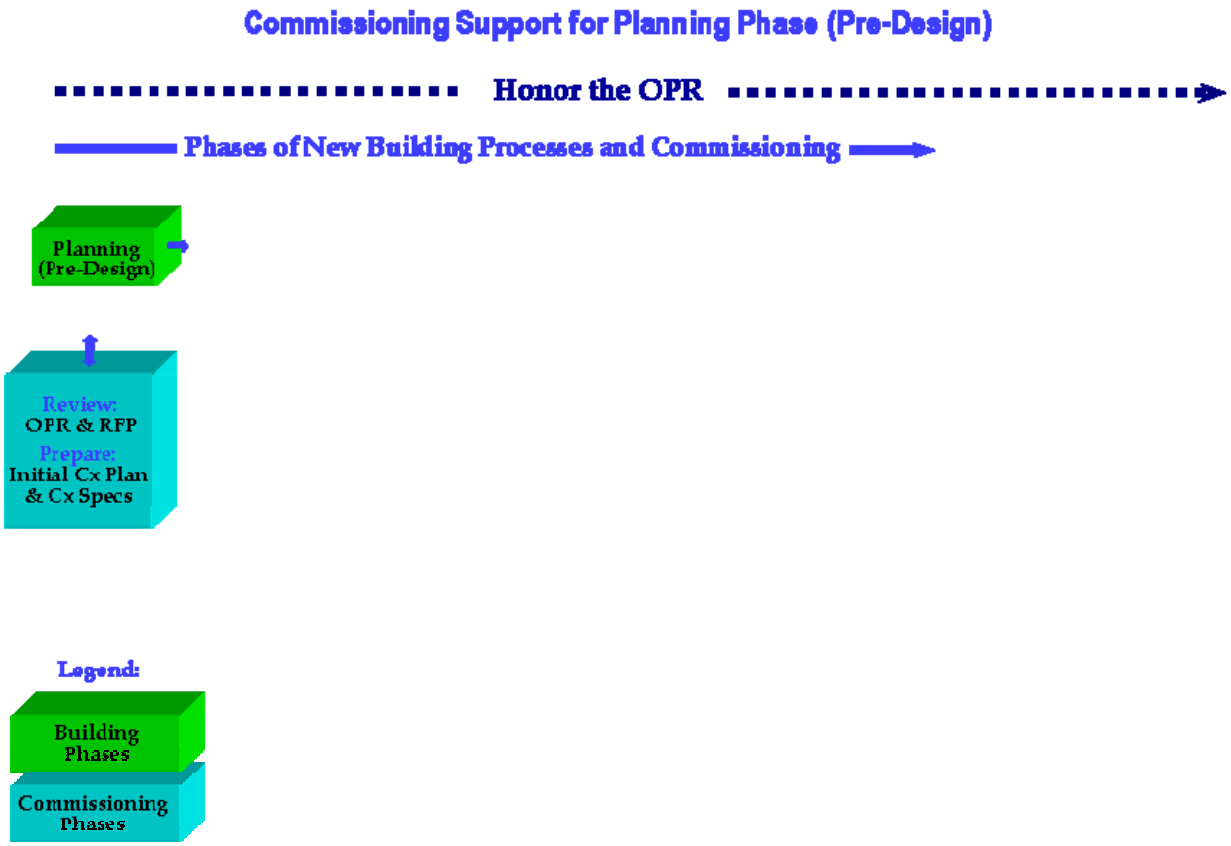


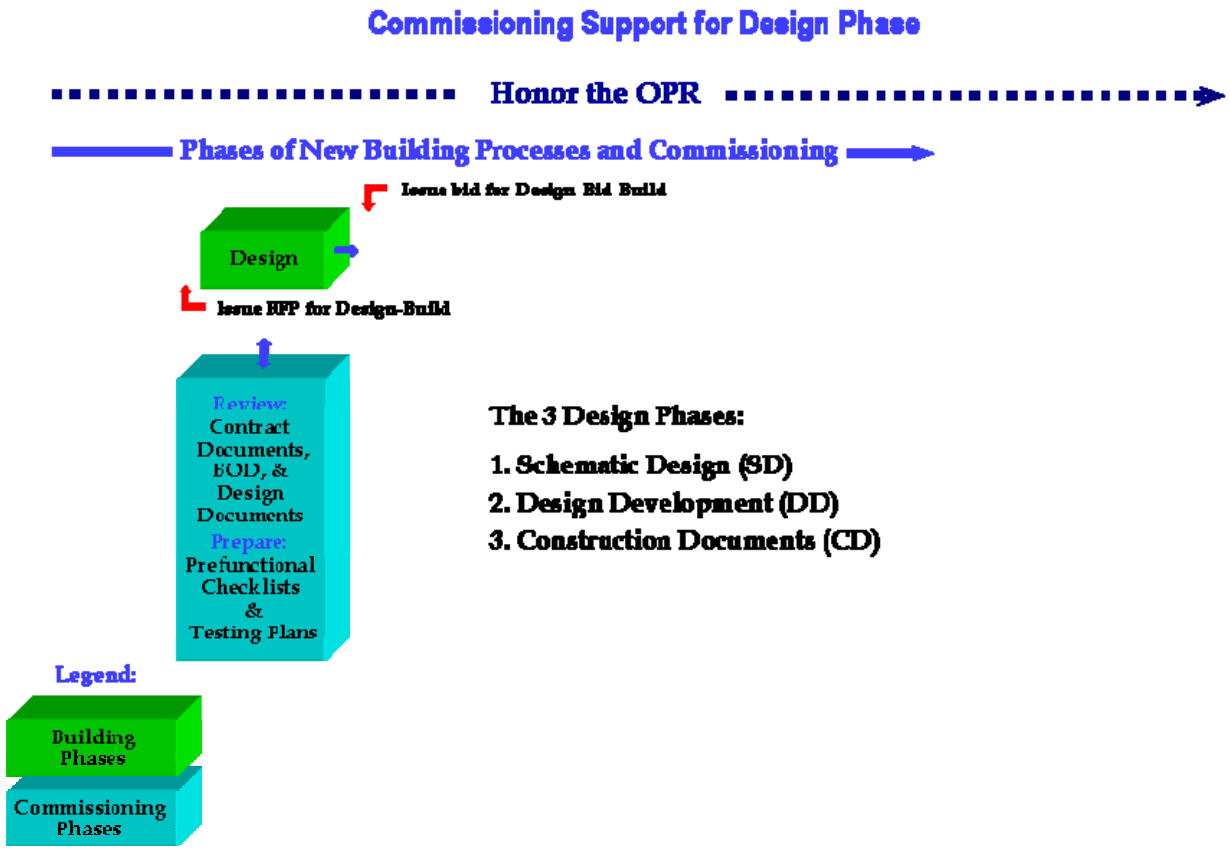
Figure B-5: Time spans of engagement in the Cx process for inner and outer core Cx team members during the building phases for new construction. Dotted lines denote intermittent Cx engagement, whereas solid lines indicate continuous engagement.

- Note that figure pertains to timelines for Cx activities, not traditional roles (e.g. designers engage continuously in their design role, but intermittently in their Cx team role)
- Intermittency is associated with Cx meetings, reviews, and other Cx tasks that are scheduled for short spans at various points in time during the building phases
- Upstream quality is embodied in activities done at the planning and early design phases (as emphasized previously), and is assured by intermittent, but structured, Cx tasks and meetings during those early phases
- PMB, BPM, DSS, and CSS through their respective roles are vital to ensuring upstream quality, through an intermittent, scheduled Cx process that is economic in time expenditure
- During the downstream construction phase, PMB and BPM (with support from CSS) make embedded upstream quality "stick" through continuous Cx engagement with contractors
- Relationship and interaction between PMB and BPM are vital to quality assurance

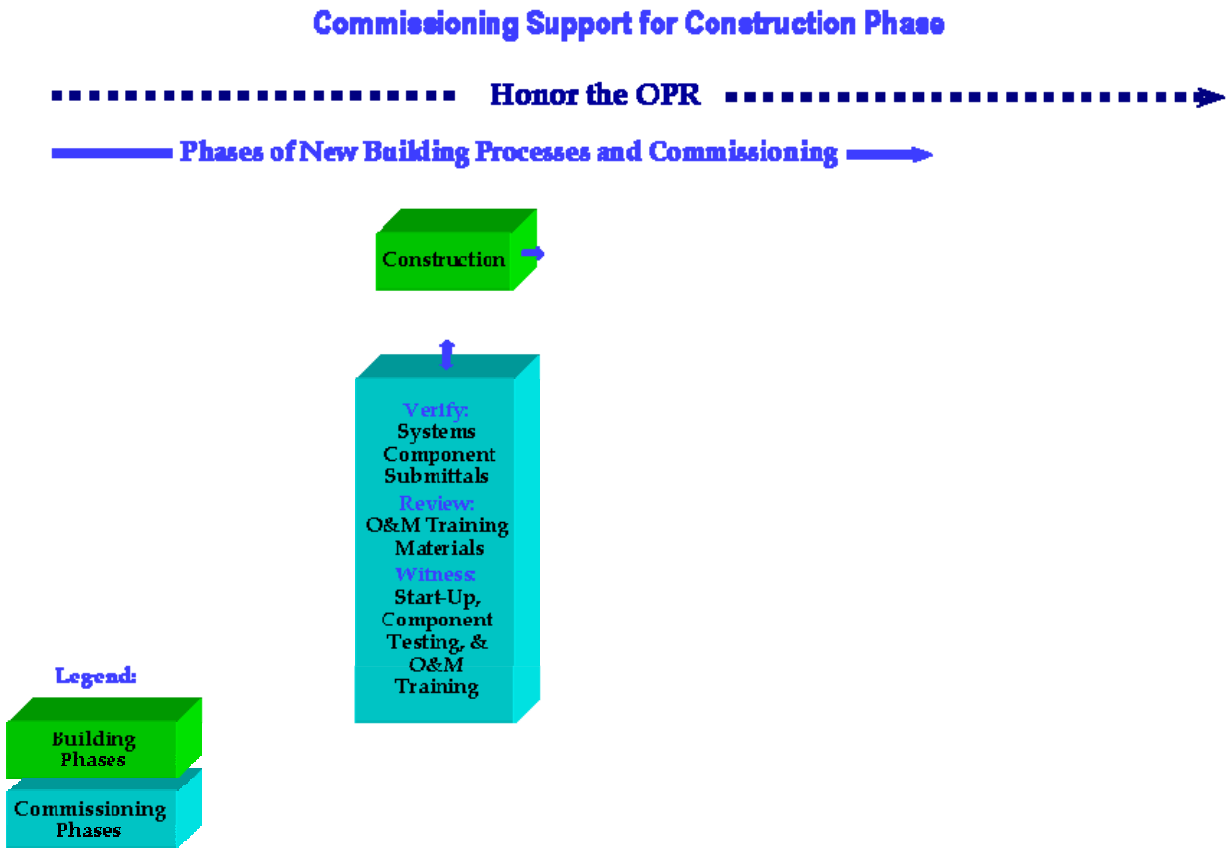
- Note intermittent Cx engagement for outer core Cx team members, except for contractors, who engage continuously with PMB and BPM in Cx processes during construction



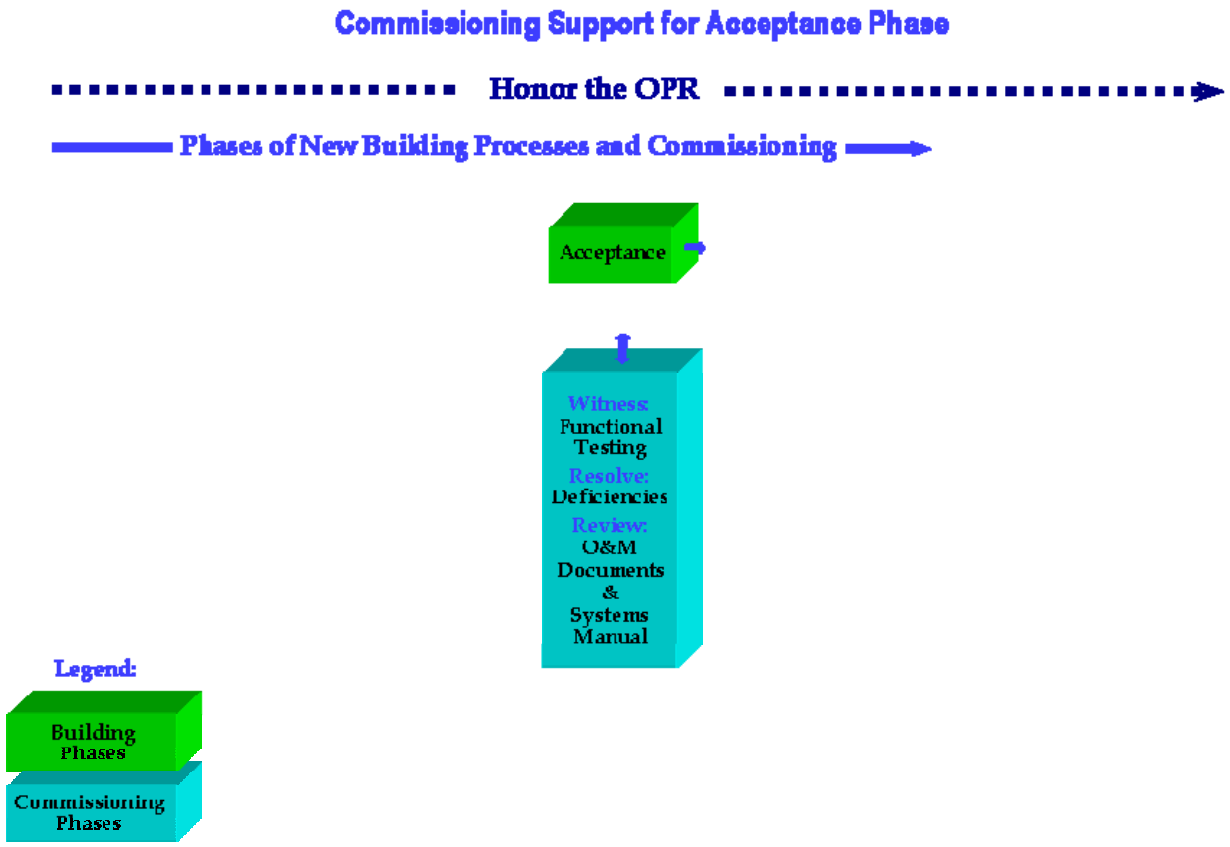
- Cx team (outer and inner core) is formed and includes all stakeholders relevant to earliest building phases (see Fig. B-5).
- Budget package is developed; process includes CxA team.
- RFP is developed early and contains project narrative that will guide development of OPR.
- At this step, key stakeholders from Cx team are outer core members that include owner and occupant reps, project planners and designers, and inner core members that include PMB, BPM, DSS, and CSS (see Fig. B-5).
- CxA team reviews RFP and OPR, once developed.
- CxA team prepares initial Cx Plan and Cx Specifications.



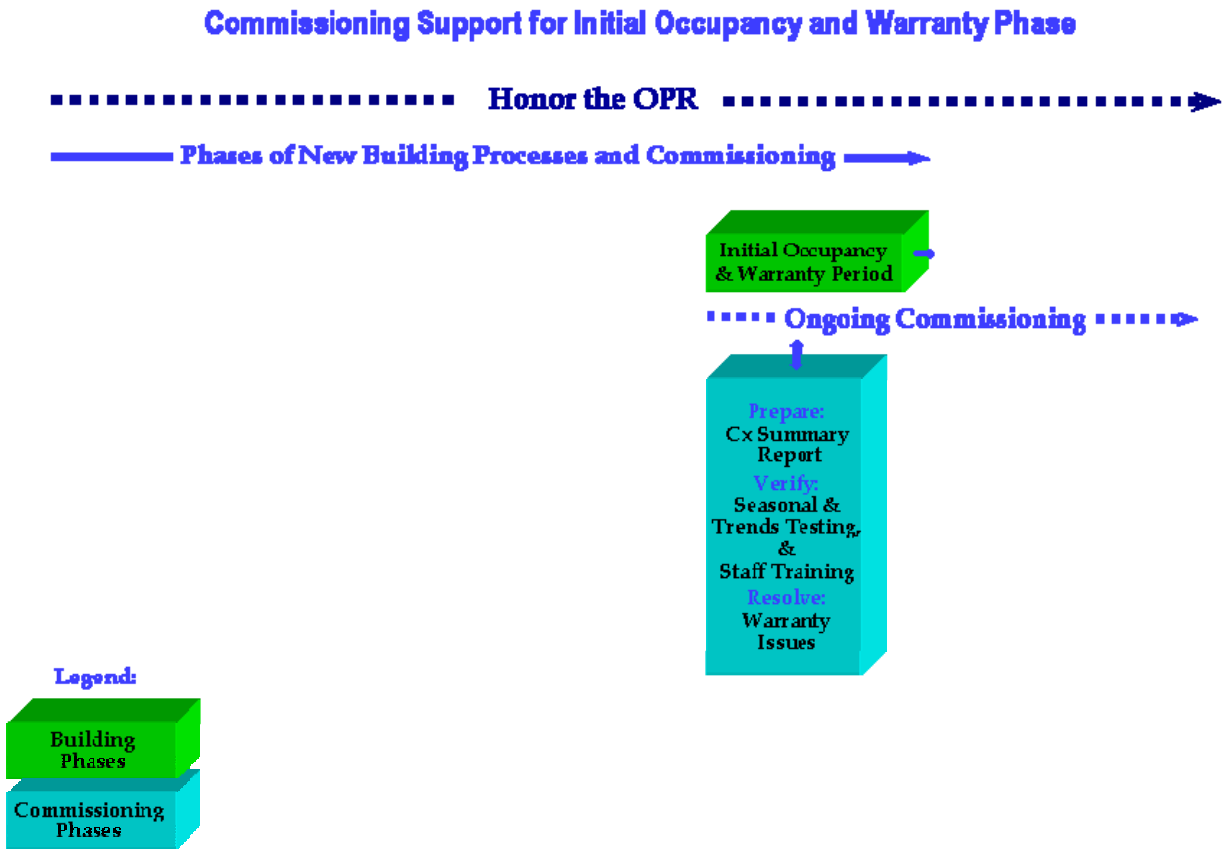
- Process varies for Design-Bid-Build versus Design-Build (see figure above)
- Basis of design (BOD), guided by OPR, is developed by project designers and reviewed by CxA team
- Design reviews performed by key CxA team members that includes DSS, with support from Building Manager and Chief Engineer from BPM
- Schematic design (SD) documents are reviewed by key CxA team members (1-5 days)
- Design development (DD) documents are reviewed by key CxA team members (1-5 days)
- Construction documents (CD) are reviewed by key CxA team members (1-5 days)
- Contract documents reviewed by CxA team
- CxA team develops pre-functional checklists for components and systems
- CxA team initiates development of functional testing plans (also referred to as validation testing plans)



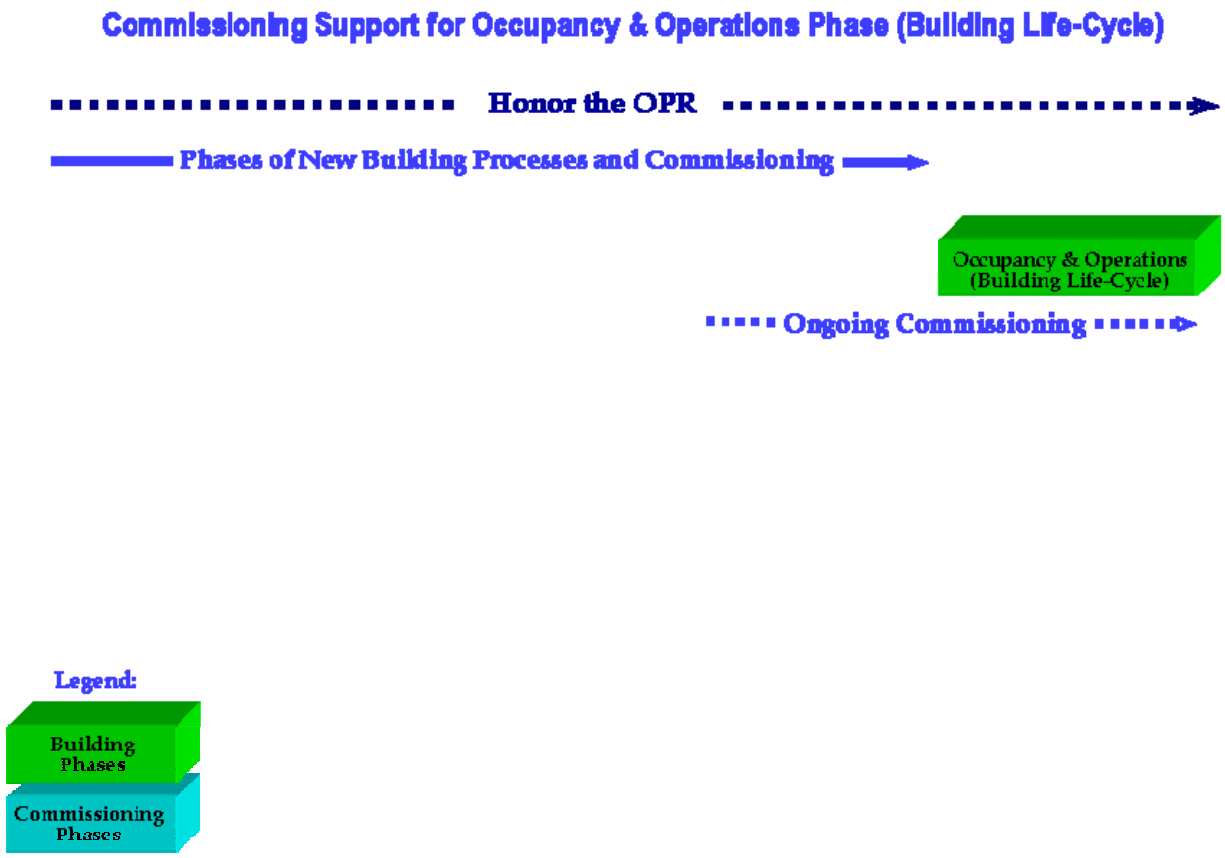
- Key CxA team members verify systems component submittals as compliant with OPR and BOD prior to installation
- O&M training material developed by contractor is reviewed by key on-site CxA team members
- Start-up and component testing witnessed by key onsite CxA team members
- O&M training witnessed by key on-site CxA team members



- Key on-site CxA team members witness functional testing of building systems and controls
- Issues log of deficiencies is created by key on-site CxA team members
- Deficiencies are resolved by contractor with guidance from key on-site CxA team members
- O&M documents and overall Systems Manual is reviewed by key on-site CxA team members
- Acceptance of building and its functional systems is given by CxA team



- Occupancy of building occurs
- Contractor prepares seasonal trends and testing, which is reviewed by CxA team
- Staff training is verified by key on-site CxA team members
- Warranty issues are resolved during the warranty period
- Formal commissioning process is completed
- Final Cx Report is prepared by CxA team to capture and summarize Cx processes on project



- O&M personnel (BPM) operate and maintain the building over its life-cycle
- Ongoing commissioning is performed by O&M personnel, guided by a fault detection diagnostics (FDD) system tied into the building automation system (BAS)
- Periodic renovations occur as circumstances dictate

Integrating Building Commissioning into State Building Construction

Appendix C: Definitions and Narratives of Key Terms in the Commissioning Process

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Note: This appendix contains definitions and narratives of key terms employed in the commissioning process. Reference to this material is critical to fully understanding and implementing the material in Appendix B on the sequences, procedures, and essential documents employed in building commissioning. Appendix D contains key commissioning document forms. The reader is also referred to ASHRAE Guideline 0-2005: The Commissioning Process.

Basis of Design (BOD):

The Basis of Design (BOD) stems from the OPR and links the OPR with construction documents (CD). The BOD contains both narrative and detailed technical information. The BOD is developed by the project design team, with review by the commissioning authority (CxA) team. It is developed incrementally through the planning and design phases of a project, up through the development of construction documents (CD).

The objective of the BOD is to provide all relevant stakeholders at each phase of a project with an explanation and understanding of the reasoning for the selection specific building features, components, assemblies, and systems, and their integration into effective whole-building performance.

Commissioning (Cx) Plan:

The Cx Plan, written by the CxA team, structures the organization, scheduling, resource allocation, and required documentation for the entire commissioning process. The plan lays out roles and responsibilities for all members of the Cx team. The plan is developed early on and revised, only as appropriate, in the design phases up until construction documents. Vitally, it is critical to establish a Cx plan with upstream quality as the embodied goal.

Commissioning (Cx) Specifications:

The Commissioning (Cx) Specifications document, written in coordination with the CxA team and the owner's representative (or project director) supplements the Cx Plan. In the view of some, the Cx Specifications are really a part of the Cx Plan, and contain details on specifications for commissioning targeted building systems. The Cx specs also assign detailed roles and responsibilities for the general contractor, installing subcontractors, design team, and other relevant members of the Cx team.

Design Reviews:

Members of the CxA that are designers or O&M engineers serve to review design submittals at all three design phases: schematic design (SD), design development (DD), and construction documents (CD). Design submittals are provided by the general contractor to the CxA team. Design reviews at each phase can take from 1 day to a week, depending on the scale and complexity of the building.

Functional Performance Tests (FPTs):

Function Performance Tests (FPTs), which are also known as validation tests, follow prefunctional checking on site, and ensure that all building systems and controls function

correctly under various conditions and modes of operation. FPT plans are developed by the contractor or the CxA team, following manufacturer's guidance, and reviewed by the CxA team, as appropriate. If a building component or system substantially fails the PFT, the installing subcontractor is required to remedy the situation. Retesting is then done. For practical reasons in functional performance testing, spot testing is performed. However, some components and systems, such as air handing units (AHUs) are all tested. Consult ASHRAE Guidelines 0-2005 and 1.1-2007, for guidance on functional performance testing.

Issues Log:

The Issues Log is a document that captures all deficiencies found on-site and recorded by an appropriate member of the CxA team member. It includes all deficiencies found in components or systems that are not compliant with the parameters specified in the functional performance test plans and design documents. The issues log becomes part of the punch list, and will detail the required adjustments or alterations to correct system operation. Responsible parties for deficiency resolution are identified in the log. Resolutions are noted in the log when completed.

Owners Project Requirements (OPR):

Formerly referred to as design intent, the OPR guides and drives the commissioning process. It is essentially in a narrative format, and speaks to the purpose and function of the building and represents advocacy for: a) the building owner; b) the comfort and productivity of the building's occupants; and c) the effectiveness of the operations and maintenance (O&M) crew over a building's life cycle. As evident in the figures in Appendix B depicting the commissioning sequences, the OPR is to be honored at all steps from start to finish of a building construction project.

In practice, the OPR often has been a weak or nonexistent component of the commissioning process, despite its ostensible central role. A main reason is that owners and occupants frequently are unable to articulate an effective OPR. Thus, it is critical to formalize the creation of an OPR within the commissioning framework. This should entail an OPR workshop with engagement of the right stakeholders, specifically owner and occupant representatives, key members of the commissioning authority (CxA) team, and the Project Director (PD).

Note: The pursuit of LEED certification also serves to "inform" the OPR along dimensions of "green" and sustainability.

Prefunctional Checklists (PFCs):

The Prefunctional Checklists (PFCs) are documents are prepared by the contractor or CxA team in preparation for function testing (also referred to as validation testing). In the spirit of embedded upstream quality, the PFCs, if followed correctly by the installing contractors, minimize failures (hence costs) at functional testing. PFCs include start-up sheets, testing and balance (TAB) checklists, and controls checklists.

Short-Term Diagnostic Testing:

Short-term diagnostic testing, using data acquisition equipment or building automaton system (BAS) entails recording trends over a 2-3 week period to investigate dynamic interaction between components in the building system. Inefficiencies and otherwise hard to predict operating flaws can be difficult to discover without short-term trend analysis.

System Component Submittals:

Before installation during the construction phase, the contractor provides submittals to the CxA team of the components to be installed in the building. Appropriate members of the CxA team review the submittals to assure they satisfy the OPR and BOD.

Summary Commissioning (Cx) Report:

The Summary Commissioning (Cx) Report extends the Cx Plan to include relevant data and information that is useful for the operation and maintenance (O&M) crew in the continued operation of the building. It includes general project information, Cx team information, an executive summary of the C process, outstanding issues, history of deficiencies, and other pertinent information.

Systems Manual:

The Systems Manual is a comprehensive manual that includes: a) the final OPR and BOD for the project; b) the Operations and Maintenance (O&M) Manual for the as-built condition of the building; c) other documents of relevance for review and guidance over the life-cycle of the building.

Training Manuals:

The Training Manuals are developed by the contractor for training the O&M personnel in the operation and maintenance of the building's components, systems, and controls. The CxA team reviews the manuals for content and process.

Integrating Building Commissioning into State Building Construction

Appendix D: Forms for the Sequential Commissioning Steps in a DGS Capital Outlay Project

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SECTION 01 91 13

GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

B. OPR and BoD documentation are included by reference for information only.

1.02 SUMMARY

A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.

B. Related Sections:

1. Division 23 Section "Commissioning of HVAC" for commissioning process activities for HVAC&R systems, assemblies, equipment, and components.
2. Division 26 Section "Commissioning of Electrical Systems" for commissioning process activities for electrical systems, assemblies, equipment, and components.

1.03 DEFINITIONS

A. BoD: Basis of Design. A document that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

B. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

C. CxA: Commissioning Authority.

D. OPR: Owner's Project Requirements. A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

E. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.

1.04 COMMISSIONING TEAM

A. Members Appointed by Contractor: Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to

implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, representatives of Contractor, including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.

B. Members Appointed by Owner:

1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
2. Representatives of the facility user and operation and maintenance personnel.
3. Architect and engineering design professionals.

1.05 OWNER'S RESPONSIBILITIES

A. Provide the OPR documentation to the CxA and Contractor for information and use.

B. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.

C. Provide the BoD documentation, prepared by Architect and approved by Owner, to the CxA and Contractor for use in developing the commissioning plan, systems manual, and operation and maintenance training plan.

1.06 CONTRACTOR'S RESPONSIBILITIES

A. Contractor shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:

1. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.
2. Cooperate with the CxA for resolution of issues recorded in the Issues Log.
3. Attend commissioning team meetings held on a weekly basis.
4. Integrate and coordinate commissioning process activities with construction schedule.
5. Review and accept construction checklists provided by the CxA.
6. Complete electronic construction checklists as Work is completed and provide to the Commissioning Authority on a weekly basis.
7. Review and accept commissioning process test procedures provided by the Commissioning Authority.
8. Complete commissioning process test procedures.
9. Prior to substantial completion, complete commissioning functional testing, with the exception of deferred seasonal testing, with Owner approval.

1.07 CxA'S RESPONSIBILITIES

A. Organize and lead the commissioning team.

B. Provide commissioning plan.

C. Convene commissioning team meetings.

D. Provide Project-specific construction checklists and commissioning process test procedures.

E. Verify the execution of commissioning process activities using random sampling. The sampling rate may vary from 1 to 100 percent. Verification will include, but is not limited to, equipment submittals, construction checklists, training, operating and maintenance data, tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, the CxA will report the failure in the Issues Log.

F. Prepare and maintain the Issues Log.

G. Prepare and maintain completed construction checklist log.

H. Witness systems, assemblies, equipment, and component startup.

I. Compile test data, inspection reports, and certificates; include them in the systems manual and commissioning process report.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 91 11

Owner's Project Requirements (OPR)

Project Name:

Address:

Owner:

Design Team:

Architect:

Mechanical Engineer:

Electrical Engineer:

Lighting Designer:

Kitchen Consultant:

Commissioning Agent:

Sustainability Consultant:

Other _____ :

Summary Description *(insert from project narrative)*

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2. Building Systems Selected for Commissioning 2
3. General Building Design 3
4. Energy Design Objectives 5
5. HVAC System Requirements 6
6. Lighting Design Parameters 10
7. Interior Performance Criteria Summary 12

Purpose

The Owner's Project Requirements (OPR) establishes a baseline of performance expectations for the building. The project requirements were collectively developed by the building owner and the design team as part of the overall design requirements for the project. This document addresses the design goals, design requirements, and performance expectations for the building systems and components that have been selected for commissioning.

The designated design team member(s) responsible or capable of best answering the questions for each section or item in the OPR are delineated by an acronym in the table below.

Owner	**OWN**
Architect	**ARCH**
Mechanical Engineer	**ME**
Electrical Engineer	**EE**
Lighting Designer	**LD**
Commissioning Agent	**CxA**

Building Systems Selected for Commissioning

The following systems have been selected for commissioning: **(CxA)**

HVAC Systems

___ Packaged equipment and controls
___ Building automation system
___ Other _____

Electrical Systems

___ Electrical distribution
___ UPS
___ Back-up power generation
___ Lighting controls
___ Other _____

Life Safety Systems

___ Fire alarms
___ Fire suppression
___ Smoke evacuation
___ Other _____

Miscellaneous

___ Security system
___ Elevator equipment and controls
___ Telecommunication system
___ Kitchen equipment
___ Other _____

General Building Design

A. Describe the overall design objectives for this facility. **(OWN, ARCH)**

B. Describe any special or unique requirements or conditions that had to be addressed in the design of this facility. **(OWN, ARCH)**

C. List all applicable client design standards or design criteria: **(OWN, ARCH, ME, EE, LD)**

D. How will the facility address sustainability and minimal environmental impact? **(OWN, ARCH)**

E. What is the expected occupant loading by space type? Please list or attach a schedule. **(ARCH)**

_____
_____
_____
_____
_____
_____
_____

F. What design tools or design aides are expected to be used in this project for those systems to be commissioned? (i.e.: energy modeling, lighting modeling, etc,) **(ME, EE, LD)**

_____
_____
_____
_____
_____
_____
_____

Energy Design Objectives

A. Describe any overall energy performance design objectives for this facility. **(ME, ARCH, OWN)**

B. Is a sustainability rating, (such as the U.S. Green Building Council's Leadership in Energy and Environmental Design) desired for this facility? If so, what LEED certification level is desired by the client or the design team? **(ARCH, OWN)**

C. What is the target total energy usage per square foot per year? **(ME, ARCH, OWN)**

D. What is the target total energy cost per square foot per year? **(OWN, ME, EE)**

D. Is kW demand control specifically a concern of the client or the design team; and if so, for what reason? **(EE, ME, OWN)**

HVAC System Requirements

A. What is the desired thermostatic set-point range in the heating season, and cooling season? **(ME)**

B. List the HVAC system types considered desirable to the design team, and ones that are not to be considered. **(ME)**

C. What is the expected occupancy schedule? Will the occupants be allowed to override the mechanical system controls during "unoccupied hours"? **(ME, OWN)**

D. Are there times during the day that the zone temperature is allowed to drift out of the temperature set-point range? If so, how long and what times are acceptable. **(ME, OWN)**

E. How many days out of the year is it acceptable to not meet the entire cooling load? **(OWN)**

F. Are there zones with special temperature, humidity, air filtering, etc., requirements? If so, identify and list the special environmental control requirements. **(ME, OWN)**

G. Is a building automation system (BAS) desired? If so, what are the requirements of the BAS and what value is expected to be added with the BAS? **(ME, OWN)**

H. Does the owner or design team have a preference for a building-wide digital control for the BAS system, or local (stand-alone) control? **(ME, OWN)**

I. Will zone set-points be controlled locally by the user, or via the BAS only adjustable by the maintenance staff? **(ME, OWN)**

J. Is it acceptable to let the facility cool down to a night setback temperature in the winter? **(ME, OWN)**

K. Is it acceptable to let the facility temperature drift above set-point during the summer evenings? **(ME, OWN)**

L. Explain the requirements of the HVAC system in regards to temperature, humidity and draft control. **(ME)**

M. Explain the requirements of the facility with regard to indoor air quality. **(ME)**

N. What are the acoustic requirements of the HVAC system within the various spaces of the facility? **(ME)**

_____
_____
_____
_____
_____
_____
_____

O. Describe the maintenance plan and how the HVAC design needs to address operation and maintenance issues. **(ME, OWN)**

_____
_____
_____
_____
_____
_____
_____

P. Indicate the level of priority given to the following design criteria for the HVAC system. **(ME, OWN)**

Comfort:	Lowest	1	2	3	4	5	Highest
Energy Efficiency:	Lowest	1	2	3	4	5	Highest
Indoor Air Quality:	Lowest	1	2	3	4	5	Highest
Noise:	Lowest	1	2	3	4	5	Highest
Ease of Reconfiguration:	Lowest	1	2	3	4	5	Highest
Maintenance Cost:	Lowest	1	2	3	4	5	Highest
First Cost:	Lowest	1	2	3	4	5	Highest
Life Cycle Cost:	Lowest	1	2	3	4	5	Highest
Durability/Reliability:	Lowest	1	2	3	4	5	Highest
Other ( ):	Lowest	1	2	3	4	5	Highest

Comments:

_____
_____
_____
_____
_____

Lighting Design Parameters

A. What is the target lighting foot-candle level in each occupancy type? **(EE, LD)**

B. What is the target lighting design wattage per square foot in each occupancy type? **(EE, LD)**

C. Is daylighting a criterion for design? Explain. **(EE, LD)**

D. What is the primary reason for using daylighting? **(EE, LD)**

- ☐ Energy savings
- ☐ View/aesthetics
- ☐ Occupant satisfaction/well-being
- ☐ Visual light quality

E. What is the lighting system design approach (i.e. task / ambient, uniform, etc.)? **(EE, LD)**

F. Describe the integration of lighting systems with architectural elements (ceiling, partitions, physical daylighting features, etc.)? **(EE, LD, ARCH)**

G. Are the occupants likely to be flexible with regards to lighting levels? **(OWN)**

H. Do any spaces have special or unique lighting requirements? If so, please explain. **(LD)**

I. Who should have access for adjusting light levels? **(LD,OWN)**

J. Where are these adjustments made? **(EE, LD)**

Interior Performance Criteria Summary

Record the design interior conditions in the following table for each defined space type. **(ME, EE, LD, ARCH, OWN)**

Space Type	People per 100 sf	Operating Hours per Day	Heating Setpoint	Cooling Setpoint	OSA CFM / Person	Design Light Level (FC)

Basis of Design (BOD)Summary

Project Name:

Address:

Owner:

Design Team:

Architect:

Mechanical Engineer:

Electrical Engineer:

Lighting Designer:

Kitchen Consultant:

Commissioning Agent:

Sustainability Consultant:

Other _____ :

Summary Description:

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Purpose

The Basis of Design Summary (BOD) is a response by the design team describing how the design has met the Owner's Project Requirements (OPR). This information defines the performance expectations of the building systems selected for commissioning. The OPR, developed collectively by the building owner and the design team, established the overall design requirements for the project. The Basis of Design Summary addresses the underlying assumptions, regulatory requirements, and performance expectations for the building systems and components that have been selected for commissioning. The designated design team member(s) responsible or capable of best answering the questions for each section or item in the BOD are delineated by an acronym in the table below.

Owner	**OWN**
Architect	**ARCH**
Mechanical Engineer	**ME**
Electrical Engineer	**EE**
Lighting Designer	**LD**
Commissioning Agent	**CxA**

Building Systems Selected for Commissioning

The following systems have been selected for commissioning: **(CxA)**

HVAC System (and all integral equipment controls)

___ Boiler system
___ Hot water pumps
___ Computer room packaged air handling units
___ Variable air volume air handling units with gas heat
___ Variable air volume (VAV) boxes, interior
___ VAV boxes with reheat, perimeter
___ Air cooled condensing units
___ Radiant heat
___ Exhaust fans
___ Cabinet unit heaters
___ Unit heaters
___ Building automation system (controlled devices, control loops and system integration)

Electrical Systems

___ Main switchboard circuit breakers, grounding system
___ Transformers
___ UPS and back-up power generation
___ Low voltage cable
___ Other _____

Life Safety Systems

___ Fire alarm system
___ Fire suppression systems
___ Smoke evacuation
___ Other _____

Miscellaneous

___ Card access security system
___ Elevator equipment and controls
___ Intrusion detection system
___ Telecommunication system
___ Kitchen equipment
___ Exhaust hood and makeup air systems
___ Appliance power connections and rated input
___ Confirm temperatures of selected hot and cold equipment
___ Irrigation system
___ Building envelope
___ Renewable energy systems
___ Other _____

Applicable Codes and Design Standards

List all applicable local, state and/or federal building codes. **(ME, EE, ARCH)**

Building Code: _____

Mechanical Code: _____

Electrical Code: _____

Plumbing Code: _____

Energy Code: _____

LEED Rating: _____

Other:_____

Other:_____

HVAC System

Load Calculations and Design Criteria (ME)

What outdoor design conditions were assumed for design load calculations?
Summer: DB_____ WB_____ Winter: DB_____
What indoor design conditions were assumed for load calculations?
Summer: DB_____ RH_____ Winter: DB_____ RH_____
What is the total facility cooling capacity requirement (Tons or BTUH)? _____
What is the total facility heating capacity requirement (BTUH)?_____

A. How were computers factored into the interior energy load calculations? Were "Energy Star" computers considered or flat monitor screens? What was the basis of the assumed plug load power density? What diversity factor was assumed?

_____
_____
_____

B. What is the expected total energy usage per square foot per year?

_____

C. What is the expected total energy cost per square foot per year?

_____

D. What overall safety factor was used for the heating and cooling equipment capacities and fan sizes?

_____
_____
_____

E. How much diversity (lighting, plug loads, etc.) was assumed for the heating and cooling equipment capacities and fan sizing?

_____
_____
_____

F. For redundant equipment, what redundancy criteria were used?

_____

_____

_____

Interior Design Parameters and Conditions (ME)

Record the design interior conditions in the following table for each defined space type.

Space Type	People per 100 sf	Operating Hours per Day	Heating Setpoint (ºF)	Cooling Setpoint (ºF)	Btu/hr/ Person Sensible	Btu/hr/ Person Latent	Infiltration Cf/sf Wall Area or ACH	OSA CFM / Person	Internal Plug Load W/sf	Design Light Level (FC)	Internal Lighting Load W/sf

Systems Descriptions (ME)

A. Provide a narrative of the entire HVAC system and areas served (i.e. central, packaged, CV, VAV, multi-zone, reheat type, etc.).

B. Describe the overall philosophy and underlying reasoning leading to the HVAC system selection and design for this facility.

C. Explain how the design described above incorporates the owner's requirements of energy efficiency, comfort and cost as explained in the Design Intent Summary.

D. Provide a narrative of the hot water and chilled water plant and distribution systems.

E. Describe the overall philosophy and underlying reasoning leading to the plant design for this facility.

_____
_____
_____
_____
_____
_____

F. How will the required outside air intake quantity be maintained in the VAV systems under low flow conditions?

_____
_____
_____
_____
_____

G. Is any special equipment or designs included to maintain healthy indoor air quality?

_____
_____
_____
_____
_____

H. What has been done to reduce maintenance in the HVAC system?

_____
_____
_____
_____
_____

I. Describe how building static pressure is controlled (setpoints, etc.).

_____
_____
_____
_____
_____

J. Regarding heat transfer / recovery equipment, provide a general description and any special features (high efficiency, face velocity, low pressure drop, etc.).

_____
_____
_____
_____
_____

K. Is a supply air reset strategy going to be implemented? If so, what will the reference variable(s) be?

_____
_____
_____
_____
_____
_____

L. Are any other reset strategies being implemented in the HVAC system?

_____
_____
_____
_____
_____

M. Describe the perimeter reheat system, areas served, etc.

_____
_____
_____
_____
_____
_____

N. What type of economizer control has been are designed into the system? (temperature, enthalpy, integrated, etc)

_____
_____
_____
_____
_____

O. Explain the sequence of operation. Include sequences that directly apply to meeting the design intent regarding indoor air quality, comfort, energy use criteria.

P. Are there any additional energy saving features in the HVAC equipment not already addressed in this document?

Building Automation System (ME)

A. Describe the overall philosophy and underlying reasoning leading to the control system design for this facility.

B. Provide a general description of the control system for this facility. (i.e. DDC, electronic, pneumatic, protocols, interoperability, etc.).

C. Explain how the control system selected will facilitate meeting the design intent.

_____
_____
_____
_____
_____
_____
_____
_____

D. Explain the interaction and/or communication that will occur between any factory controls provided with equipment, and the BAS.

_____
_____
_____
_____
_____
_____
_____
_____

E. Check the energy conserving control strategies that will be implemented in this building through the BAS.

☐	Holiday scheduling	☐	Occupancy-based outside air control
☐	Zonal scheduling	☐	DX compressor optimization
☐	Sequential startup of equipment	☐	Mixed air temperature control
☐	Lighting sweep	☐	Boiler staging and optimization
☐	Night setup/setback	☐	Heat element (coil) staging
☐	Optimum start	☐	Hot water reset
☐	Optimum stop	☐	Heat recovery option control
☐	Hot & cold deck reset (supply air)	☐	Variable speed pump control
☐	Air-side economizer control	☐	Occupancy based HVAC control
☐	Night ventilation purge / pre-cooling	☐	Demand limiting or load shedding
☐	CO2 outside air rate control	☐	Duty cycling of equipment
☐	Full trending capabilities	☐	DHW recirculation pump control
☐	Other: (describe)	☐	DHW temperature control

Lighting and Daylighting

Electric Lighting Systems (EE)

A. What are the design illumination levels at the workplane (30 inches above finished floor) in the various spaces:

Area	Design Illumination (FC)

B. Describe the interior electric lighting system:

_____
_____
_____
_____

C. Is a dedicated lighting control system proposed? If so, describe:

_____
_____
_____
_____

D. Describe the exterior (site) electric lighting system:

_____
_____
_____
_____

E. What is the expected energy or cost saving due to the electric lighting and daylighting designs?

_____
_____
_____
_____

F. What is the expected lighting power density (watt per square foot) for the entire facility by space type?

_____

_____

G. What color temperature will be specified for the lamps?

_____

_____

H. What color rendering index will be specified for the lamps?

_____

_____

I. Is task lighting being used? If so, explain the design.

_____

_____

_____

J. Are there special glare requirements for the electric lighting design, and how have they been addressed?

_____

_____

_____

_____

_____

K. How will glare from windows, skylights, etc., be controlled in daylit areas?

_____

_____

L. What are the parameters and sequences of operation for the daylighting controls and dimming lights? How will occupants interact with the system (overrides, education, etc.)?

_____

_____

_____

_____

_____

M. What areas of the building have dimming control?

_____

_____

_____

N. Can occupants override the dimming? If so, how?

_____
_____

O. Who has access for adjusting light levels?

_____
_____

P. Are photosensors utilized in the system? If so, where are the sensors located?

_____
_____
_____

Q. How will the electric lighting integrate with the daylighting in regards to lamp color and control?

_____
_____
_____
_____

Daylighting Systems (EE)

A. Describe the daylighting design and performance expectations:

_____
_____
_____
_____

B. Will the daylighting design require active shade or glare control? If so, describe: ?

_____
_____
_____
_____

C. How much of the electrical lighting load is expected to be offset with daylighting?

_____
_____
_____
_____

D. What areas will be daylit, and how was this decision made?

_____
_____
_____
_____
_____

E. Describe related architectural lighting features such as light shelves, sloped ceilings, skylights, special interior finishes, etc.

_____
_____
_____
_____

Service Water System

If applicable **(ME)**

Renewable Energy Systems

If applicable **(ME)**

Building Envelope

If applicable **(ME)**

Service Water System

If applicable **(ME)**

Commissioning Plan
For
Project Name
In City, State

Prepared for xxxxx:

Address

Prepared by xxxxxx:

Contact
Location

Version 1.0

Project Name
Commissioning Plan

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PUBLICATION RECORD

Revision	Date	Author	Description & Summary of Changes
Original			

Overview

Abbreviations and Definitions

The following are common abbreviations used in this document.

A/E	Architect and design engineers	FPT	Functional performance test
CXA	Commissioning Agent	CM	Construction Manager
CC	Controls contractor	MC	Mechanical contractor
CX	Commissioning	PF	Pre-functional checklist
EM	Energy manager	Subs	Subcontractors to General
CX Plan	Commissioning Plan document	TAB	Test and balance contractor
EC	Electrical contractor	Staff	Maintenance Staff
MM	Maintenance Manager		

Where the term "contractors" is used in the CX Plan, it refers to the CM and/or Subs as appropriate.

Purpose of the Commissioning Plan (CX Plan)

The purpose of the CX Plan is to provide direction for the commissioning process during construction, providing resolution for issues such as scheduling, roles and responsibilities, lines of communication and reporting, approvals, and coordination.

Commissioning Goals and Objectives

Commissioning is a systematic process of ensuring that the building systems perform according to the Basis of Design (BOD) and the Owner's Project Requirements (OPR). All equipment and systems should be installed according to manufacturer's recommendations, the best practices and standards of the industry, and the Contract Documents.
Commissioning will include documenting the, followed by activities in the construction, acceptance, and warranty phases of the project. The participation of the contractors in commissioning activities will follow the requirements defined in the specifications. The three main goals of the commissioning process are:

1. Facilitate the final acceptance of the project at the earliest possible date.
2. Facilitate the transfer of the project to the owner's maintenance staff.
3. Ensure that the comfort systems meet the requirements of the occupants.

Commissioning is also intended to achieve the following specific objectives:

- Document that equipment is installed and started per manufacturer's recommendations.
- Document that equipment and systems receive complete operational checkout by installing contractors.

- Document system performance with thorough functional performance testing and monitoring.
- Verify the completeness of operations and maintenance materials.
- Ensure that the owner's operating personnel are adequately trained on the operation and maintenance of building equipment.

LEED Rating and Commissioning

The commissioning effort for this project will also include meeting all of the USGBC LEED commissioning requirements:
The LEED section on "Energy and Atmosphere" has a prerequisite of "Fundamental Building Systems Commissioning." In addition, the LEED rating system has a credit available for "Enhanced Commissioning." The LEED prerequisite commissioning requirement addresses the fundamental commissioning process, with specific reference to the following:

1. Engage a Commissioning Authority. According to the specific requirements outlined in the LEED reference guide, this individual shall be independent of the project's design and construction management, though they may be employees of the firms providing those services.
2. Develop Owner's Project Requirements and Basis of Design documentation.
3. Include commissioning requirements in the construction documents.
4. Develop and utilize a Commissioning Plan.
5. Verify installation, functional performance, training and documentation.
6. Complete a Commissioning Report.

The LEED Enhanced commissioning credit requirement addresses commissioning activities during the design and post-occupancy phases, with specific reference to the following:

7. Conduct a focused review of the design prior to the Construction Documents Phase.
8. Conduct a selective review of contractor submittals of commissioned equipment.
9. Develop a system and energy management manual (Re-Commissioning Manual).
10. Verify that the requirements for training operating personnel and building occupants are completed.
11. Have a contract in place for a near-warranty end or post occupancy review.

Architectural Energy Corporation's preliminary commissioning plan assumes that these best practices commissioning activities will be performed as an integral part of the scope of commissioning services this project.

Commissioning Equipment Scope

The systems to be commissioned include: All general references to equipment in this document refer only to equipment that is to be commissioned.

- ☐ HVAC components and equipment
  - HVAC systems: interaction of cooling, heating, and comfort delivery systems.
  - Building Automation System (BAS): control hardware and software, sequence of operations, integration of factory controls with BAS
  - Air Handling Units
  - VAV Terminal Boxes
  - Fan Powered Terminal Boxes
  - Fans
  - Chilled Water Tie-in
  - Steam Tie-in
  - Heat Exchangers
  - Pumps
  - Split A/C Units
  - Unit Heaters
- ☐ Lighting Controls
  - Occupancy sensors
  - Daylight sensors
  - Central lighting control system
  - Daylight interaction of electric lighting and daylight design elements
- ☐ Domestic Hot Water Systems
  - Solar Domestic hot water system
- ☐ Emergency Generator
- ☐ Central Utility Plant (CUP)

Note: The CUP is included due to a LEED requirement, but commissioning services for the CUP will not include all of the scope outlined in this Statement of Work for the Liberal Arts Building equipment. Instead the CUP-related activities will be those necessary to fulfill the LEED requirements, which include only a cursory review of the CUP's five year operation maintenance record and energy performance data. If this data cannot be provided or if the information reflects an unsatisfactory condition, a separate scope of work for more extensive testing can be developed.

General Building Information

Project Name	

Project Address	
Building Type	
Square Footage	
Building Description	
Owner	

Roles and Responsibilities

General Management Plan

The CXA coordinates the commissioning activities and will report to the owner's representative. The CXA whether contracted through the design team or otherwise is accountable for following a professional pact with allegiance to the building owner to help coordinate the delivery of a fully functional building in alignment with the Owner's Project Requirements and the Contract Documents.
The CXA's responsibilities, along with the designation of the CX Team, are detailed in the Separate Scope of Commissioning Work. The CX process will require the coordinated effort of all members of the CX Team in order to meet the objectives of the Contract Documents.

General Descriptions of Roles of the CX Team

General descriptions of the commissioning roles are as follows:

CXA	Coordinates the CX process, writes and reviews testing plans, directs and documents performance testing.
A/E	Perform construction observation, approve O&M manuals and assist in resolving problems.
Owner	Responsible for final approval of the CX work
MM	Coordinates maintenance staff participation in commissioning activities
Staff	Participate in commissioning tasks and performance testing, review O&M documentation, and attend training.
CM (Cx Coordinator)	Facilitates the CX process, ensures that Subs perform their responsibilities and integrates CX into the construction process and schedule.
Subs	Demonstrate correct system performance
TAB	Test and balance appropriate systems, as outlined in TAB contract
Mfr:	Equipment manufacturers and vendors provide documentation to facilitate the commissioning work and perform contracted startup.

Specifications and Commissioning

Commissioning language in the specifications and in the Separate Scope of Commissioning Work details the scope of commissioning for this project. The following lists the sections of the specifications that include commissioning related language with a brief description.

Section 01 33 00 - Submittal Procedures
Section 01 75 00 - Starting and Adjusting
Section 01 17 70 - Project Closeout
Section 01 78 00 - Closeout Submittals
Section 01 78 23 - Operation and Maintenance Data
Section 01 79 00 - Demonstration and Training
Section 01 91 00 - Commissioning
Section 23 05 93 -Testing, Adjusting and Balancing for HVAC
Section 23 08 00 - Commissioning of HVAC
Section 23 09 00 - Instrumentation and Control for HVAC

General Management Plan and Protocols

The following protocols will be used on this project.

Issue	Protocol
For requests for information (RFI) or formal documentation requests:	The CXA goes first through the CM and Owner.
For minor or verbal information and clarifications:	The CXA goes direct to the informed party.
For notifying contractors of deficiencies:	The CXA documents deficiencies through the CM and Owner
For scheduling functional tests or training:	The CXA provides input and coordination of testing and training. Scheduling is done through the CM.
For scheduling commissioning meetings:	The CXA selects the date and schedules through the CM and Owner.
For making a request for significant changes:	The CXA has no authority to issue change orders.
For making minor changes in specified sequences of operations:	All changes in sequences of operations required must be approved by the A/E. The CXA may recommend changes in sequences of operation to correct operational deficiencies and/or to improve efficiency or control.
Subcontractors disagreeing with	Resolve issues at the lowest level possible. First

requests or interpretations by the CXA shall:	with the CXA, then with the CM and Owner. Some issues may require A/E input.

Commissioning Team Responsibility Matrix and Descriptions

The responsibilities of various parties in the commissioning process are provided in this section. A Responsibility Matrix is included first, followed by a written description.

Commissioning Team Responsibility Matrix

Legend:
P = Primary responsibility / lead and / or perform activity
S = Secondary or support responsibility / assist the primary team member
R = Review documents and / or approve activities provided by others

Commissioning Team Responsibility Matrix									
P = Primary Responsibility	S = Secondary Responsibility					R = Review & Approve			
Activity	**CxA**	**Owner**	**A/E**	**CM**	**MC**	**EC/Other**	**TAB**	**CC**	**Notes**
Oversee & facilitate commissioning process; serve as Commissioning Team leader.	P								
Pre-Design Phase									
Develop Basis of Design documents	R	P	P						
Develop Owner's Project Requirements document	S	P	S						
Design Phase									
Prepare CxP	P	R	R	R					
Prepare commissioning specifications	P	R	R	R					
Integrate commissioning specifications into the design	S		P						
Update the Commissioning Plan	P	R	R						
Perform Design Reviews	P	S	S	S					
Coordinate commissioning activities with schedule	P			P	S	S	S	S	
Construction Phase									
Conduct Pre-bid and Pre-con Cx kickoff meetings	P	S	S	S	S	S	S	S	
Coordinate commissioning activities into the master construction	S			P					
Attend commissioning team meetings as needed	P	P	S	P	P	P	S	S	
Review and Revise CxP	P	R	R	R					
Review submittals of commissioned equipment and systems – for project acceptance.		S	P	S					
Review submittals and shop drawings for commissioning related use.	P								
Write and distribute PFC sheets for commissioned equipment and systems.	P	R	R	R					

Commissioning Team Responsibility Matrix									
P = Primary Responsibility	S = Secondary Responsibility						R = Review & Approve		
Activity	**CxA**	**Owner**	**A/E**	**CM**	**MC**	**EC/Other**	**TAB**	**CC**	**Notes**
Write and distribute Equipment List / Matrix	P	R		R					
Perform PFC's and submit completed check sheets	R	R			P	P		P	
Audit PFC's of major and primary equipment; sample of secondary equipment	P				S	S		S	
Perform site observations with respect to commissioning	P	S	S	S					
Provide equipment startup procedures	R	R			P	P		P	
Perform equipment startups	R	R			P	P		P	
Prepare and maintain the Commissioning Issues Database	P	R	S	S	S	S	S	S	
Witness or review equipment start-ups	S	S		S	P			S	
Perform duct leakage testing	R			R	P				
Perform pipe pressure testing	R			R	P				
Review completed PFC check sheets	P								
Acceptance Phase									
Provide standard test instrumentation for commissioning	P								
Provide ladders and proprietary test equipment to CxA as required				P	P	P		P	
Develop PFT's for commissioned systems and equipments	P	R	R						
Perform PFT's and submit completed tests	P	S			S	S		P	
Provide written responses to open issues in the Deficiencies Log	R		P	P	P	P	P	P	
Update Deficiencies Log	P								
Correction of deficiencies and open issues	R				P	P	P	P	
Prepare TAB plan	R		R				P		
Perform TAB work							P		
Review TAB report	S		P						
Spot test TAB readings in field	P						S		

Commissioning Team Responsibility Matrix									
P = Primary Responsibility		S = Secondary Responsibility					R = Review & Approve		
Activity	CxA	Owner	A/E	CM	MC	EC/Other	TAB	CC	Notes
O&M Activities									
Define training requirements.		S	P						
Provide training materials and syllabus.				P	P	P		P	
Review training materials.	P	S							
Provide training sessions.				P	P	P		P	
Attend training.	S	P		P	P	P		P	
Verify and document training.	P								
Provide O&M manuals.				S	P	P		P	
Review O&M manuals.	P	P	P						
Provide as built drawings.				S	P	P		P	
Review as built drawings		P	P						
Post Acceptance Phase									
Prepare final commissioning report.	P								
Prepare Systems Manual.	P		R	R	R	R	R	R	
Short Term Diagnostic Testing	P								This activity is provided, if necessary, to evaluate system performance. It is a less rigorous M&V scope.
Warranty Phase									
Develop Energy Plan (M&V Plan), / Implement plan and provide report.	P							S	This activity falls under a separate M&V scope, if selected.
Develop procedures for seasonal functional / performance testing.	P								
Execute seasonal functional performance tests.	P				P	P		P	
Interview building staff.	P								
Prepare Commissioning Warranty report.	P								
Correction of deficiencies and open issues.					P	P	P	P	

Commissioning Agent (CXA)

The CXA is not responsible for design concept, design criteria, code compliance, general construction scheduling, cost estimating, or construction management. The CXA may assist with problem-solving deficiencies, but ultimately that responsibility resides with the CM and the A/E team. The primary role of the CXA is to develop and coordinate the execution of a testing plan to verify and document that systems are functioning in accordance with the Basis of Design and the Construction Documents.

Construction and Acceptance Phase

- Coordinates and directs all commissioning activities. Work with the CM and Owner to ensure that commissioning activities are scheduled.
- Maintain an up-to-date CX Plan.
- Plan and conduct the commissioning scoping meeting.
- Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures, and sequences of operation.
- Review Contractor submittals applicable to commissioned systems.
- Develop start-up and checkout plans with Subs. Write and distribute pre-functional checklists.
- Perform site visits, as necessary, to observe component and system installations. Attend construction job-site meetings, as necessary, to monitor construction and commissioning progress.
- Review completed pre-functional checklist and start-up reports.
- Assist with coordination of start-up requirements with TAB requirements.
- Write functional performance test procedures for equipment and systems.
- Coordinate, witness, and document functional performance tests completed by installing contractors. Coordinate retesting as necessary until satisfactory performance is verified.
- Maintain a master deficiency and resolution record. Provide the CM and Owner with written progress reports and test results with recommended actions.
- Review the training proposed by the contractors for the Owner's operating personnel.
- Review the O&M manuals.
- Prepare a final commissioning report.

Owner

Construction and Acceptance Phase

- Arrange for facility operating and maintenance personnel to participate in commissioning activities and training sessions.
- Provide final approval for the completion of the commissioning work.

Warranty Period

- Work with CM and CXA to facilitate seasonal and deferred testing and to address deficiency issues.

Design Team (A/E)

Construction and Acceptance Phase

- Attend commissioning scoping meeting and additional meetings, as necessary.
- Provide Basis of Design and sequence of operation documentation as required by the CXA.
- Assist in resolution of system deficiencies identified during commissioning.
- Review and approve the operations and maintenance manuals.
- Optional: Review equipment start-up and pre-functional checklists. Review functional performance test plans. Witness performance testing.

Warranty Period

- Assist in resolution of system deficiencies identified during warranty period commissioning.

Construction Manager (CM) – Commissioning Coordinator

Construction and Acceptance Phase

- Facilitate the coordination of the commissioning work by the CXA.
- Attend commissioning scoping meeting and additional meetings, as necessary.
- Furnish copies of construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CXA.
- Ensure that Subs execute their commissioning responsibilities according to the Specifications, CX Plan and Separate Scope of Commissioning Work.
- Coordinate the training of owner personnel.
- Prepare O&M manuals, according to the Specifications, including updating original sequences of operation to as-built conditions.

Warranty Period

- Ensure that Subs execute required seasonal or deferred functional performance testing.
- Ensure that Subs correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified during the warranty period.

Mechanical, Electrical, Controls Contractors

Construction and Acceptance Phases

- Attend commissioning scoping meeting and additional meetings, as necessary.
- Provide additional requested documentation, prior to normal O&M manual submittals, to the CXA for development of start-up and functional testing procedures.
- Assist in clarification of operation and control of commissioned equipment where the specifications control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- Develop a start-up and checkout plan for all commissioned equipment based on manufacturer's recommendations and pre-functional checklists from the CXA. Submit to CXA for review and approval prior to startup.
- During the startup and checkout process, execute the mechanical-related portions of the pre-functional checklists for all commissioned equipment. Perform and clearly document all completed startup and system operational checkout procedures.
- Resolve A/E punch list items before functional testing.
- Perform functional performance testing, under the direction of the CXA, for commissioned equipment.
- Resolve equipment or system deficiencies and retest as required to verify modified performance.
- Prepare O&M manuals according to the Specifications, including updating original sequences of operation to as-built conditions.
- Provide training of the Owner's operating personnel as specified.
- Coordinate with equipment manufacturers to determine requirements to maintain the validity of warranties.

Warranty Period

- Execute seasonal or deferred functional performance testing, as necessary.

- Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified during the warranty period.

TAB Contractor

- Air and water TAB shall be completed with discrepancies and problems resolved before functional testing.
-

Controls Contractor

The commissioning responsibilities of the controls contractor, during construction and acceptance phases are:

1. Sequences of Operation Submittals.

   The temperature controls submittals shall include complete and detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
   a. A narrative description of the system, describing its purpose, components and function.
   b. Interactions and interlocks with other systems.
   c. Delineation of control interactions between packaged controls and the building automation system, including a listing of monitored points, controlled points, and adjustable points.
   d. Written sequences of control for packaged controlled equipment.
   e. Sequences of control for all modes of operation (Start-up, Warm-up, Cool-down, Normal occupied, Unoccupied, Emergency Shutdown, etc.).
   f. Capacity control sequences and equipment staging.
   g. Temperature and pressure control sequences (setbacks, resets, etc.).
   h. Sequences for all control strategies (economizer control, optimum start/stop, optimization, demand limiting, etc.).
   i. Effects of power or equipment failure with all standby component functions.
   j. Sequences for alarms and emergency shutdowns.
   k. Seasonal operational requirements.

2. Control Drawings Submittal

   a. The control drawings shall have a key to all abbreviations.
   b. The control drawings shall contain graphic schematic depictions of the systems and each component.
   c. The schematics will include the system and component layout of all equipment that the control system monitors, enables or controls,

even if the equipment is primarily controlled by packaged or integral controls.

d. Provide a full points list with at least the following included for each point:

1) Controlled system
2) Point abbreviation
3) Point description
4) Point type (digital/analog, input/output)
5) Display unit
6) Control point or setpoint (Yes / No)
7) Monitoring point (Yes / No)
8) Intermediate point (Yes / No)
9) Calculated point (Yes / No)

3. An as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.
4. The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing.
5. Provide a signed and dated certification to the CXA and CM upon completion of the control system checkout.

Equipment Suppliers

- Provide requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in effect.
- Provide information requested by CXA regarding equipment sequence of operation and testing procedures.
- Assist in equipment testing per agreements with contractors.

Commissioning Process

This section sequentially details the commissioning process by commissioning task or activity.

Prepare Commissioning Plan

The Commissioning Plan describes the implementation of the commissioning process and provides a framework for integration of commissioning activities into the construction and acceptance process. The Commissioning Plan also provides an agenda for organizing and focusing the commissioning scoping meeting. The Commissioning Plan expands to incorporate more information as the design, construction, and acceptance and warranty phases of the facility are

completed. The Commissioning Plan will be updated during the construction and warranty phases.

The Commissioning Plan will include, at a minimum, the following information:

- A brief overview of the commissioning process.
- A list of all commissioned features and systems.
- Identification of the commissioning team and its responsibilities.
- A description of the management, communication, and reporting of the commissioning process.
- An outline of the commissioning scope, including: development of the owner's project requirements, review of the basis of design, schematic design, construction documents and submittals, construction phase verification, functional performance test development and implementation, and ten-month warranty review.
- A list of the expected work products.
- A list of key commissioning milestones.

Documentation of Owner's Project Requirements and Basis of Design

A clear Owner's Project Requirements (OPR) report is critical to the commissioning process. The OPR defines the benchmark for system performance. It is a detailed explanation of the information developed for the Owner’s program, focused on those systems included in the scope of work for commissioning. It will clearly define the functional and indoor environmental quality requirements. The Basis of Design document details the Design Team’s response to the performance criteria in the Owner’s program and OPR report. It will include the heating, ventilation, and air-conditioning requirements for each occupancy type, with references to applicable codes and standards, and other design criteria used as the "basis of design" for other building systems to be commissioned. These documents are to be requested from the Owner and Design Team and will review them for completeness and for future reference as they are integral to the project delivery process, or as required, assist the Design Team to create the necessary deign intent and basis of design reports.

Design Review

The design documents review is undertaken to ensure that commissioning is adequately specified within the construction documents for those building systems to be commissioned, and that the targeted building systems are likely to meet the design goals (intent) relative to functionality, energy performance, maintainability and indoor environmental quality.

The intent and timing of these reviews is to identify and resolve any issues that may adversely impact the installation, operation and performance of the equipment and building systems to be commissioned before the construction

documents are completed and used for construction purposes. Design reviews can be provided for all major document submissions, including programming, SD, DD, CD phases, and at a minimum the 100% DD and 95% CD submissions.

Throughout this scope the CxA will participate in the Design process to help facilitate the incorporation of technological advancements into the building design.

Develop Commissioning Specifications

Commissioning specifications for the targeted building systems will be prepared by the Owner with assistance from the CxA, or can be provided by CxA if needed. In addition to the distinct Commissioning Specifications, the CxA will also review the Training, Close Out Documents, and O&M specifications. The proposed specifications will be reviewed for completeness and adequacy relative to defining the commissioning requirements of the general contractor and all installing subcontractors. The commissioning specifications describe the scope and requirements for commissioning, as well as the roles and responsibilities of the general contractor, installing subcontractors, Owner personnel, Design Team, and the Commissioning Team. The Training, Close Out Documents, and O&M specifications support the Commissioning specifications by defining requirements of the Owner's turn over requirements.

Commissioning Scoping Meeting

The CxA will hold a scoping meeting at pre-bid and post-notice to proceed which will bring together all members of the design and construction team that will be involved in the commissioning process. Each building energy system to be commissioned will be addressed, including its intended operation, commissioning requirements, and completion and start-up schedules. During the scoping meeting, all parties agree on the scope of work, tasks, schedules, deliverables, and responsibilities for implementation of the Commissioning Plan.

Commissioning Kickoff Meeting

A commissioning kickoff meeting will be held on the jobsite and will be run by the CM and CxA. This meeting will include all applicable sub-contractors that are involved in the commissioning process. The CxA and the Developer will be present to answer questions and help in the discussion as needed. During this meeting, the CM will advise the contractors of their roles in this process, and will explain what tasks and milestones have been added to the "standard" construction process as a result of the developer including commissioning in their scope. The CM will direct the contractors to the Cx specification and will clear up any questions that may arise as a result of the specification. It is expected that the CM will be prepared and will be familiar with the commissioning specification and its requirements, and will be able to clearly explain what the contractors need to do to participate. Prior to this kickoff meeting, the CxA will be available to the CM to aid in their understanding of the commissioning requirements.

This meeting will be scheduled by the Developer, CM and CxA and should occur prior to the installation of piping and ductwork

Commissioning Plan (Cx Plan)

The CxA finalizes the draft Cx Plan using the information gathered from the scoping meeting. The initial commissioning schedule is also developed along with a detailed timeline. The timeline is fine-tuned as construction progresses. The CM is requested to update the CxA regularly with construction schedules, and to include pre-functional checkout and functional performance testing in the master schedule.

Submittals Review

The CM will provide the CxA with a set of equipment and system submittals. The CxA will review the submittals for completeness and check that the submitted equipment meets the OPR and BOD. This equipment data includes installation and start-up procedures, O&M data, performance data and temperature control drawings. The CM, Subs, or A/E notify the CxA of any new Basis of Design or operating parameter changes, added control strategies and sequences of operation, or other change orders that may affect commissioned systems.

The CxA review comments will get forwarded to the design engineer of record for that particular system. The design engineer then determines which comments are to be forwarded to the CM and contractor and also determines if the review comment requires re-submittal or not.

Jobsite Observations

Onsite observations are conducted as needed to verify compliance with manufacturer's installation and start-up instructions and recommendations, compliance with the Basis of Design, and meeting the requirements for efficient operation and maintenance. Testing and balancing (TAB) observation will verify TAB methods and procedures on both air-side and water-side systems. Commissioning will also include verification of the TAB as a prerequisite to substantial completion. The verification procedure will spot check (10% sampling rate) air and water flow rates at locations selected by the commissioning engineer. For this activity, The TAB contractor will complete the measurements and provide the same instrument that was used when the original data was collected. Construction observation is not for the express purpose of ensuring compliance with codes and standards.

Refer to Appendix B for an example of a Jobsite Observation Report.

Pre-functional Checklists

A Pre-Functional Inspection Checklist will be developed by the CxA and be completed by the appropriate sub-contractor for all major equipment and systems

being commissioned. The checklist confirms the as-built status of the equipment or system and ensures that the systems are complete and operational, so that the functional performance testing can be scheduled. An Owner provided cover page template will be provided for incorporation or addition to the CxA checklist. Manufacturer's start-up checklists and other technical documentation guidelines will be used as the basis for all pre-functional checklists. The checklists will be updated as required during the project development or new checklists will be generated if new equipment is added (major equipment additions, are subject to a fee increase).

The CxA will review and verify the completed Pre-Functional Inspection Checklists before beginning the functional performance testing. A 10% sampling of onsite verification will be preformed. In addition, the CxA will be present for the major on-site manufacturer's equipment start-up. These activities will be coordinated with the design mechanical and electrical engineers' punch list activities. An Equipment matrix, which includes the equipment to be commissioned as part of this scope, will be provided by the CxA or the contractor and tracked by the contractor.

Refer to Appendix C for an example of a Pre-Functional Checklist.

Functional Performance Testing

Functional performance testing verifies the intended operation of individual components and system interactions under various conditions and modes of operation. Functional Performance Testing Plans will be prepared by the CxA so that the complete sequence of operations is included in the test procedures. This also includes, Integrated Systems Test Plans as necessary. The Tests will be updated as required during the project development or new Tests will be generated if new equipment is added (major equipment additions, are subject to a fee increase).

Under the supervision of commissioning staff, the installing subcontractor performs the hardware and/or software manipulations required for the testing. Commissioning staff witness and record the results of functional performance testing. If a building component or system substantially fails the functional performance testing, the installing subcontractor is responsible for making the necessary system adjustments or alterations. The failed component or system will then be re-tested for conformance. It is critical that final start-up procedures, tune-up testing, air and water balancing, and control software de-bugging be complete before any functional performance testing is undertaken.

Testing, adjusting and balancing (TAB) observation will also be performed to verify TAB methods and procedures on both air-side and water-side systems. Commissioning will include verification of the balancing as a prerequisite to functional performance testing. The verification procedure will spot check air and water flow rates at locations selected by the commissioning engineer. It is

preferred that the TAB contractor will complete the measurements and provide the equipment, however the CxA will provide that scope if necessary.

Short-Term Diagnostic Testing

Short-term diagnostic testing, using data acquisition equipment or building automation system trends to record system operation over a two to three week period, may be used to investigate the dynamic interactions between components in the building system.

The monitoring occurs after occupancy to evaluate the building systems' performance under natural occupancy and ambient load conditions. The objectives of the monitoring are to evaluate scheduling, the interaction between heating and cooling, and the effectiveness of the system in meeting the comfort requirements of the occupants.

Either the building automation system or short-term monitoring equipment or both will be used to take data on selected systems. This occurs after occupancy, and any further deficiencies identified from this testing will be reported to the team for correction.

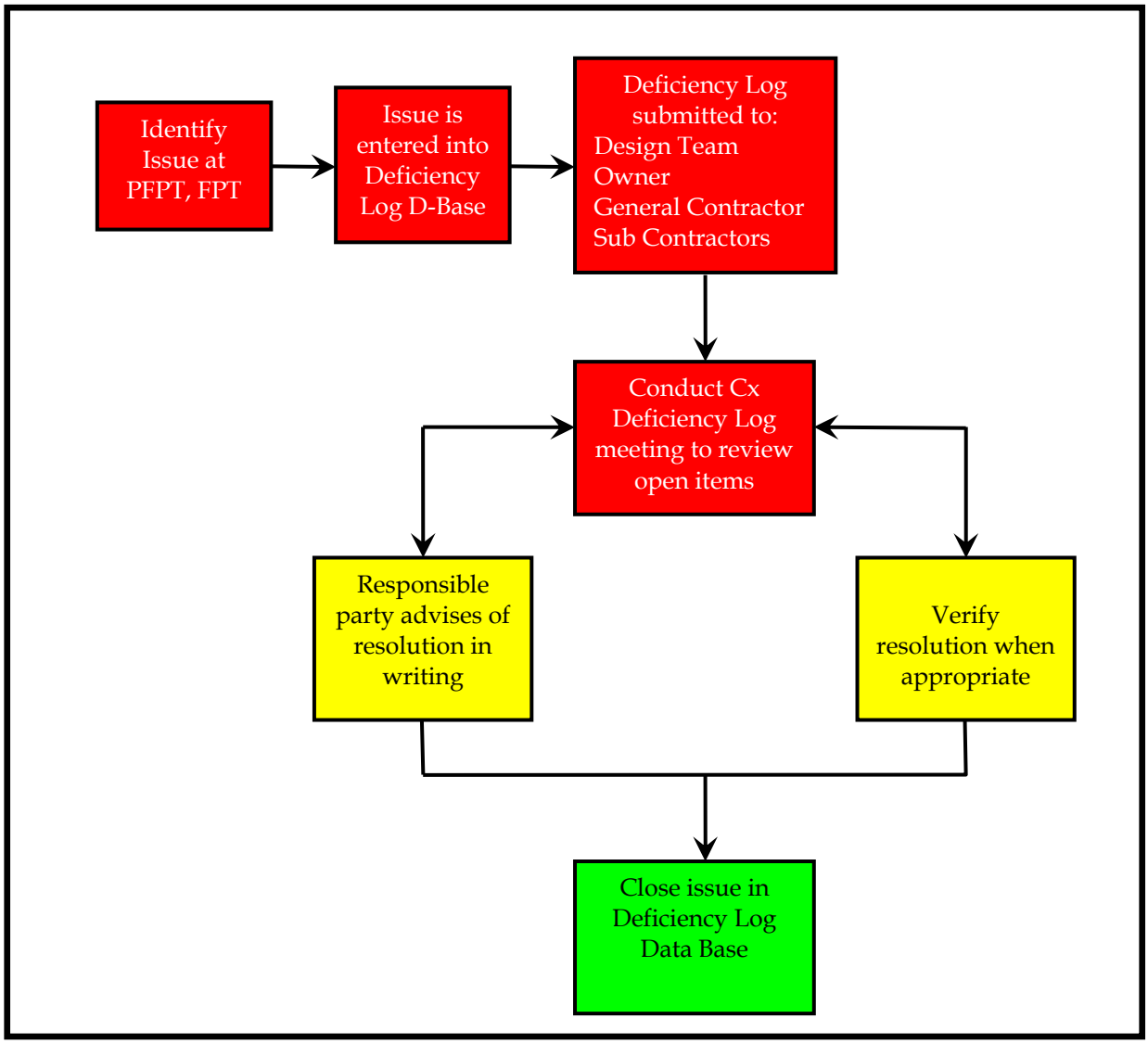
Deficiency Log and Resolution Record

The CxA and its commissioning sub-contractors will make periodic site visits to witness equipment and system installations. Each site visit will have a specific agenda and will be coordinated with the CM site supervisor. The CxA attends selected planning and job-site meetings in order to remain informed on construction progress and to update parties involved in commissioning. The CM provides the CxA with information regarding substitutions or change orders that may affect commissioned equipment or the commissioning schedule.

All deficiencies found from site visits and functional performance testing will be documented in a Deficiency Report. The report will include all details of the components or systems found to be non-compliant with the parameters of the functional performance test plans and design documents. The deficiency report will become part of the punch list. The report will detail the adjustments or alterations required to correct the system operation, and identify the responsible party. The deficiency report will be continuously updated. CxA schedules any required re-testing through the CM. Decisions regarding deficiencies and corrections are made at as low a level as possible, preferably between the CxA, sub-contractor and the CM.

Refer to Appendix E for an example of a Deficiency Log

Deficiency Log Data-Base Process



Operations and Maintenance Training

Manuals: The operation and maintenance manuals prepared by the contractors for the owner's maintenance personnel are reviewed for completeness. The contractors are encouraged to submit O&M manuals at the earliest possible date. Materials may be added, or requested from the contractors, to stress and enhance the importance of system interactions, troubleshooting, and long-term preventative maintenance and operation.

Training: Effective maintenance personnel training is critical to the long term performance of the new building. The CxA will assist the owner and CM in organizing the training sessions by identifying the appropriate staff for each session and creating an overall training plan.

For each training session, the contractors provide a detailed agenda for each piece of equipment or system for which training is required. The agenda describes the training scope, duration, and methods, along with the name and qualifications of the trainers. The CxA will develop a plan for including in the training session contractors / trainers from different disciplines, when appropriate. The trainer documents each training session (duration, general subjects covered, and attendees). The CxA may witness any of the training sessions, but will not be present for all training.

Final Commissioning Report and LEED Documentation

Final Commissioning Report: A final Commissioning Report will be compiled which summarizes all of the tasks, findings, and documentation of the commissioning process. The report will address the actual performance of the building systems in reference to the design documents. All test reports by various sub-contractors, manufacturers and controlling authorities will be incorporated into the final report.
The commissioning report includes:

- An evaluation of the operating condition of the systems at the time of functional test completion,
- Deficiencies that were discovered and the measures taken to correct them,
- Functional test procedures and results,
- Reports that document all commissioning field activities as they progressed, and
- A description and estimated schedule of required deferred testing.

LEED Documentation: LEED documentation will be compiled. Documentation will address the LEED section on “Energy and Atmosphere” prerequisite of “Fundamental Building Systems Commissioning” and the LEED section on “Best Practice Commissioning.”

Systems Manual

A Re-Commissioning Manual will be prepared by the CxA and will include all information required to effectively maintain the building at optimal performance. The Re-Commissioning Manual will include, at a minimum, the following information:

- Final version of the Owner's Project Requirements and Basis of Design
- As-built sequences of operations for all equipment as provided by the design professionals and contractors, including time-of-day schedules and schedule frequency, and detailed point listings with ranges and initial setpoints
- Ongoing operation instructions for all energy- and water-saving features and strategies

- Operating instructions for integrated building systems
- Functional performance test results, blank test forms, and recommended schedule for ongoing benchmarking
- Recommendations for recalibration frequency of sensors and actuators by type and use
- Single line diagrams of each commissioned system
- Guidelines for continuous maintenance of the Owner's Project Requirements (operational requirements) and Basis of Design (basis of operation)

Post Occupancy Review

Deferred Testing includes: Unforeseen Deferred Tests, Seasonal Testing, and End-of-Warranty Review.

Seasonal variation in operations or control strategies may require additional testing during peak cooling and heating seasons to verify system performance. During the warranty period, seasonal testing and other deferred testing is completed as required to fully test all sequences of operation. The CxA coordinates this activity. Tests are executed and deficiencies corrected by the appropriate Subs, witnessed by facilities staff and the CxA. All final adjustments to the O&M manuals and as-builts due to the testing are made.

The CxA will request input from the owner's operations staff and occupants about the performance of the building systems. The CxA also supports the CM's troubleshooting process during the warranty period. The CM's warranty team will first try and resolve the issues before requesting assistance from the CxA.

Schedule

General Issues

The following sequential priorities are followed:

1. The scheduling of commissioning activities will be coordinated to coincide with the completion of HVAC systems. Commissioning activities that address the interaction between systems will occur upon completion of all HVAC related construction.
2. Equipment is not to be "temporarily" started (for heating or cooling), until pre-start checklist items and all manufacturers' pre-start procedures are completed and moisture, dust and other environmental and building integrity issues have been addressed.
3. Manufacturer's startup procedures will be followed and documented on manufacturer provided documentation. This information will be turned over to the CM with the pre-functional checklists. Startup of equipment should be done by a manufacturer's startup technician, not a third party company.

4. HVAC and Lighting Cx: The controls system and equipment it controls are not functionally tested until all points have been calibrated and pre-functional checklists are completed. Functional Performance testing occurs only when the systems being tested are ready to be turned-over to the owner. Functional performance testing does not begin until pre-functional, start-up and TAB is completed for a given system. This activity does not begin for a system until all systems that impact the one planned for testing are complete and operational and ready to be turned-over to the owner.
5. For HVAC systems: The functional performance tests will involve the general contractor, mechanical contractor, TAB contractor, controls contractor, and maintenance personnel. The mechanical engineer is encouraged to attend to verify the systems meet the design and to provide quick resolution to questions that arise.
6. Lighting Cx: The installing contractor holds responsibility for sensor tuning and adjustment, as well as circuit and controls checkout. When all of this is complete, the functional testing of this equipment can be scheduled.

Activity Schedule

Preliminary Commissioning Schedule:

	Activity	Potential Start Date	Activity Duration
1	Commissioning Jobsite Observations		Ongoing throughout the close of project with increased frequency at last 20 months of project.
2	Duct Pressure Testing		1 week period during installation
3	Plumbing Systems Pressure Testing Chilled Water and Hot Water		1 week period during installation
4	Domestic Water Flush and Chlorination		1 week after system completion
5	Pre-Functional Checklists Filled-out by Installing Contractors		2 week period during equipment startup process
6	HVAC Equipment Startup		2 weeks
7	Controls Point-to-point checkout		2 weeks
8	Controls Sequence checkout		1 weeks

9	Lighting control checkout		1 week
10	Test Adjust and Balance		1 week
11	**Completed Pre-Functional Test Plans**		**Milestone**
12	O&M Manual Reviews		2 weeks
13	Functional Performance Testing HVAC and Plumbing		2 weeks
14	Functional Performance Testing Lighting Controls		1 week
15	Resolution of Issues Log		1 week prior to substantial completion
16	Equipment Training		1 week prior to substantial completion
17	**Substantial Completion**		**Milestone**
18	Warranty Review	10 months after Warranty Begins	2 days

Appendix A: Commissioning Team Information

Function	Name/Address	Contact Info
Owner's Representative		
Architect		
Mechanical, Plumbing, Electrical Engineer		
Commissioning Agent		**Project Manager -** Tel: 303-444-4149 Mobile: Fax: 303-444-4304 Email:
General Contractor		**Project Manager –** Tel: Email: **Superintendent –** Tel: Email: **Project Engineer –** Tel: Email:
Mechanical Plumbing Contractor TAB		**Project Manager –** Tel: Email: **Superintendent –** Tel: Email: **Project Engineer –** Tel: Email: **TAB Technician –** Tel:

Function	Name/Address	Contact Info
		Email:
Controls Contractor		**Programmer -** Tel: Email: **Tech -** Tel: Email:
Electrical Contractor		**Project Manager –** Tel: Email: **Site Super –** Tel: Email:

Appendix B: Jobsite Observation Report (Example)

Appendix C: Pre-Functional Checklist (Example)

Appendix D: Functional Performance Test (Example)

Appendix E: Deficiency Log (Example)

Division 22 – Plumbing

22 08 00 Commissioning of Plumbing

PART 1 - GENERAL

1.1 Commissioning

A. The project will have selected building systems commissioned. The equipment and systems to be commissioned are specified in Section 23 08 00. The commissioning process is described in Section 23 08 00.

Division 23 - Mechanical

23 05 93 Testing, Adjusting and Balancing for HVAC

PART 1 - GENERAL

1.1 Commissioning

A. The project will have selected building systems commissioned. The equipment and systems to be commissioned are specified in Section 23 08 00. The commissioning process and contractor responsibilities are described in Section 23 08 00.

1.2 Related Sections

1. 01 31 00 Project Management and Coordination
2. 01 33 00 Submittal Procedures
3. 01 75 00 Starting and Adjusting
4. 01 77 00 Closeout Procedures
5. 01 78 00 Closeout Submittals
6. 01 78 23 Operation and Maintenance Data
7. 01 79 00 Demonstration and Training
8. 01 91 00 Commissioning
9. 23 08 00 Commissioning of HVAC

23 08 00 Commissioning of HVAC

1.1 Commissioning

A. The project will have selected building systems commissioned. The equipment and systems to be commissioned are specified in this Section. The commissioning process and contractor responsibilities are described in this Section and the related Sections. The controls contractor shall cooperate with the commissioning authority for collection of trend data for short term monitoring. This may involve using the building automation system for a three week period of trend data collection of points specified by the commissioning authority and/or providing temporary remote monitoring capabilities of the BAS to the commissioning authority (with a temporary software license if needed).

1.2 Summary

A. Commissioning is a comprehensive and systematic process to verify that the building systems perform as designed to meet the owner's requirements. Commissioning during the construction, acceptance, and warranty phases is intended to achieve the following specific objectives:

1. Verify and document that equipment is installed and started per manufacturer's recommendations and to industry accepted minimum standards.
2. Verify and document that equipment and systems receive complete operational checkout by installing contractors.
3. Verify and document equipment and system performance.
4. Verify the completeness of operations and maintenance materials.
5. Ensure that the owner's operating personnel are adequately trained on the operation and maintenance of building equipment.

The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

The Commissioning Authority is already under contract with the architect. The general contractor that is awarded the project shall not include the cost of the Commissioning Authority in their price. The general contractor (and their sub-contractors) shall include cost for their involvement in the commissioning process including demonstration of installed equipment to the commissioning team members during the acceptance portion of the project, and other responsibilities as described in the specification.

1.3 Coordination

A. Commissioning Team. The members of the commissioning team consist of the Commissioning Provider (CP), the Owner's Representative (PM), the General Contractor (GC or Contractor), the architect and design engineers (A/E), the Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB representative (TAB), the Controls Contractor (CC), the owner's maintenance staff, and any other installing subcontractors or suppliers of equipment.

1.4 Related Sections

A. Specific commissioning requirements are given in the following sections of these specifications.

1. 01 31 00 Project Management and Coordination
2. 01 33 00 Submittal Procedures
3. 01 75 00 Starting and Adjusting
4. 01 77 00 Closeout Procedures
5. 01 78 00 Closeout Submittals
6. 01 78 23 Operation and Maintenance Data
7. 01 79 00 Demonstration and Training
8. 01 91 00 Commissioning
9. 23 05 93 Testing, Adjusting and Balancing for HVAC

1.5 Responsibilities

A. The responsibilities of various parties in the commissioning process are provided in this section. The responsibilities of the mechanical contractor, TAB and controls contractor are in Division 15 and those of the electrical contractor in Division 16. It is noted that the services for the Project Manager, Design Team, and Commissioning Authority are not provided for in this contract. That is, the Contractor is not responsible for providing their services. Their responsibilities are listed here to clarify the commissioning process.

B. All Parties

1. Attend commissioning scoping meeting and additional meetings, as necessary.

C. Architect (A/E)

Construction and Acceptance Phase

1. Attend the commissioning scoping meeting and selected commissioning team meetings.

2. Perform normal submittal review, construction observation, as-built drawing preparation, O&M manual preparation, etc., as contracted.
3. Provide design narrative documentation requested by the CA.
4. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.
5. Prepare and submit final as-built design intent documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

Warranty Period

1. Coordinate resolution of design non-conformance and design deficiencies identified during warranty period commissioning.

D. Mechanical and Electrical Designers/Engineers (A/E)

Construction and Acceptance Phase

1. Perform normal submittal review, construction observation, as-built drawing preparation, etc., as contracted.
2. Provide design narrative and sequences documentation requested by the CA.
3. Attend commissioning scoping meetings and other selected commissioning team meetings.
4. Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.
5. Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.
6. Optional: Review the equipment start-up and pre-functional checklists. Review the functional performance test plans. Witness performance testing

Warranty Period

1. Participate in the resolution of non-compliance, non-conformance and design deficiencies identified during warranty period commissioning.

E. Commissioning Authority (CA)

The CA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CA may assist with problem-solving non-conformance or deficiencies, but ultimately that responsibility resides with the general contractor and the A/E team. The primary role of the CA

is to develop and coordinate the execution of a testing plan, observe and document performance—that systems are functioning in accordance with the documented design intent and the Contract Documents.

Construction and Acceptance Phase

1. Coordinates and directs all commissioning activities in a logical and efficient manner. Work with the GC and PM to ensure that commissioning activities are being scheduled.
2. Revise, as necessary, the Commissioning Plan.
3. Plan and conduct a commissioning scoping meeting.
4. Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures, and sequences of operation.
5. Review Contractor submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews.
6. Develop start-up and checkout plan with Subs. Write and distribute pre-functional checklists.
7. Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress.
8. Review completed pre-functional checklist and start-up reports for owner approval.
9. Coordinate any start-up requirements with TAB contractor.
10. Write the functional performance test procedures for equipment and systems. Submit to PM and A/E for review.
11. Coordinate, witness, and document functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
12. Maintain a master deficiency and resolution record. Provide the PM with written progress reports and test results with recommended actions.
13. Review the training of the Owner's operating personnel.
14. Review the preparation of the O&M manuals.
15. Provide a final commissioning report.

Warranty Period

1. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.
2. Assist in the development of a preventative maintenance plan and review as-built documentation.

F. Owner's Project Manager (PM)

Construction and Acceptance Phase

1. Manage the contract of the A/E, GC, and of the CA.
2. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the Commissioning Plan.
3. Provide final approval for the completion of the commissioning work.

Warranty Period

Ensure that any seasonal or deferred testing and any deficiency issues are addressed.

G. General Contractor (GC)

Construction and Acceptance Phase

1. Facilitate the coordination of the commissioning work by the CA.
2. Furnish a copy of all construction documents, addenda, change orders and approved submittals and shop drawings related to commissioned equipment to the CA.
3. In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and training.
4. Ensure that all Subs execute their commissioning responsibilities according to the Contract Documents and schedule.
5. A representative shall attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the commissioning process.
6. Coordinate the training of owner personnel.
7. Prepare O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

Warranty Period

1. Ensure that Subs execute required seasonal or deferred functional performance testing.
2. Ensure that Subs correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for issues identified in seasonal testing.

H. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 15 are as follows:

Construction and Acceptance Phases

1. Attend a commissioning scoping meeting and other meetings necessary to facilitate the Cx process.
2. Contractors shall provide the CA with normal cut sheets and shop drawing submittals of commissioned equipment.
3. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.
4. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
5. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup.
6. During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
7. Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
8. Perform functional performance testing under the direction of the CA for specified equipment in Section 15995.
9. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, PM and A/E and retest the equipment.
10. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
11. Provide training of the Owner's operating personnel as specified.
12. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the commissioning plan.
2. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

I. Electrical Contractors. The commissioning responsibilities applicable to the electrical contractor are as follows:

Construction and Acceptance Phases

1. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Cx process.
2. Contractors shall provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment.
3. Provide additional requested documentation to the CA for development of start-up and functional testing procedures.
4. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
5. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the pre-functional checklists from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures to CA for review.
6. During the startup and initial checkout process, execute and document the electrical-related portions of the pre-functional checklists provided by the CA for all commissioned equipment. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
7. Address current A/E punch list items before functional testing.
8. Perform functional performance testing under the direction of the CA for specified equipment in Section 15995.
9. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, PM and A/E and retest the equipment.
10. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
11. Provide training of the Owner's operating personnel as specified.

12. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

1 Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.

2 Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

J. Equipment Suppliers

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
2. Assist in equipment testing per agreements with Subs.
3. Provide information requested by CA regarding equipment sequence of operation and testing procedures.

1.6 Systems to be Commissioned

A. The following checked systems will be commissioned in this project.

	Equipment and System		Equipment and System
	HVAC System		Electrical System
	Chillers		Generator
x	Pumps	x	Sweep or scheduled lighting controls
	Cooling tower	x	Daylight dimming controls
	Boilers	x	Lighting occupancy sensors
x	Piping systems		Power quality
x	Ductwork		Security system
x	Variable frequency drives		Emergency power system
x	Air handlers		UPS systems
x	Packaged units (AC and HP)		Fire and smoke alarm
x	Terminal units (air)		Fire protection systems
x	Unit heaters		Communications system
x	Heat exchangers		Public address/paging
	Computer room units		Distribution Cable
	Fume hoods		Main Breaker
	Lab room pressures		Ground Fault Detection
x	Specialty fans		Automatic Transfer Switch

	Equipment and System		Equipment and System
x	Testing, Adjusting and Balancing		
	Chemical treatment systems		
x	HVAC control system		Other
	Fire and smoke dampers	x	Service water heaters
	Indoor air quality	x	Service water booster pumps
	Equipment sound control	x	Fixtures
	Equipment vibration control		Kitchen Equipment
	Egress pressurization		Medical gas systems

PART 2 - EXECUTION

2.1 Reporting

A. The CA will provide regular reports to the PM with increasing frequency as construction and commissioning progresses.

B. A final Commissioning Report is compiled which summarizes the procedures, findings, conclusions, and recommendations of the commissioning process.

2.2 Submittals

A. The Commissioning Authority will review submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures.

2.3 Start-up, Prefunctional Checklists and Initial Checkout

A. The following procedures apply to all equipment to be commissioned, according to Section 1.6, Systems to be Commissioned.

B. General. Pre-functional Checklists are developed and completed for all major equipment and systems being commissioned. The checklist captures equipment nameplate and characteristics data, confirming the as-built status of the equipment or system. These checklists also ensure that the systems are complete and operational, so that the functional performance testing can be scheduled. The checklists are created by the CA, and completed (filled out) by the installing contractor.

C. Start-up and Initial Checkout Plan. The CA shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed.

1. The CA creates the pre-functional checklists, based primarily on the manufacturer's startup and initial checkout procedures. Each checkout item will have a place to document that proper installation has occurred. Once the pre-functional checklist is completed by the installing contractor, this signifies to the commissioning team that the equipment is properly installed per manufacturer's procedures, and the controls and TAB are complete and the equipment is ready for final functional performance testing . The Contractor determines which Sub is responsible for executing and documenting each of the line item tasks.

D. Sensor Calibration. Calibration of all sensors shall be included as part of the pre-functional checklists performed by the Contractors.

E. Execution of Pre-functional Checklists and Startup.

1. Subs and vendors schedule startup and checkout with the PM, GC and CA.
2. The CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved by the PM).
3. For lower-level components of equipment, (e.g., VAV boxes, reheat coils), the CA shall observe a sampling of the pre-functional and start-up procedures. The sampling procedures are identified in the commissioning plan.
4. The Subs and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and pre-functional checklists.
5. Only individuals that have direct knowledge and witnessed that a line item task on the pre-functional checklist was actually performed shall initial or check that item off.

F. Deficiencies, Non-Conformance and Approval in Checklists and Startup.

1. The Subs shall clearly list any outstanding items of the initial start-up and pre-functional procedures that were not completed

successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CA within two days of test completion.

2. The CA reviews the report and recommends approval to the PM. The CA shall work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The CA will involve the PM and others as necessary.

2.4 Functional Performance Testing

A. Objectives and Scope. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.

B. Development of Test Procedures. Before test procedures are written, the CA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. The CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Prior to execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection. The CA shall review owner-contracted or factory testing which the CA is not responsible to oversee and shall determine what further testing may be required to comply with the Specifications. Redundancy of testing shall be minimized.

The test procedure forms developed by the CA shall include the following information:

1. System and equipment or component name(s).
2. Equipment location and ID number.
3. Date.
4. Project name.
5. Participating parties.

6. Reference to the specification section describing the test requirements.
7. A copy of the specific sequence of operations.
8. Instructions for setting up the test.
9. Special cautions, alarm limits, etc.
10. Specific step-by-step procedures to execute the test.
11. Acceptance criteria of proper performance with a Yes / No check box.
12. A section for comments.
13. Signatures and date block for the CA.

C. Test Methods.

1. Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers. The CA will determine which method is most appropriate.
2. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.
3. Sampling. Multiple identical pieces of non-life-safety or non-critical equipment may be functionally tested using a sampling strategy. The sampling strategy will be developed by the CA and approved by the PM. If, after three attempts at testing the specified sample percentage, failures are still present, then all remaining units are tested at the contractors' expense.

D. Coordination and Scheduling. The Subs shall provide sufficient notice to the CA regarding their completion schedule for the pre-functional checklists and startup of all equipment and systems. The CA will schedule functional tests through the PM, GC and affected Subs. The CA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

E. Problem Solving. The CA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the GC, Subs and A/E team.

2.5 Documentation, Non-conformance and Approval of Tests

A. Documentation. The CA shall witness and document the results of all functional performance tests using forms developed for that purpose. Prior to testing, these forms may be provided to the PM for review and approval if the PM desires.

B. Non-Conformance.

1. The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the PM on a standard form.
2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.
3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures.
4. As tests progress and a deficiency is identified:
    a. When there is no dispute on the deficiency and the responsibility to correct it:
        1) The CA documents the deficiency and the Sub's response and intentions the testing continues. The Sub corrects the deficiency and notifies the CA that the equipment is ready to be retested.
        2) The CA reschedules the test and the test is repeated.
    b. If there is a dispute about a deficiency or who is responsible:
        1) The deficiency shall be documented on the non-compliance form and a copy given to the PM and GC.
        2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E team. Final acceptance authority is with the Project Manager.
        3) The CA documents the resolution process.
        4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency and notifies the CA that the equipment is ready to be

retested. The CA reschedules the test and the test is repeated until satisfactory performance is achieved.

5. Cost of Retesting.
   a. The cost for the Sub to retest a pre-functional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the GC.
   b. The time for the CA and PM to direct any retesting required because a specific pre-functional checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the GC, who may choose to recover costs from the party responsible for executing the faulty pre-functional test.

C. Approval. The CA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CA. The CA recommends acceptance of each test to the PM. The PM gives final approval on each test, providing a signed copy to the CA and the Contractor.

2.6 Operation and Maintenance Manuals

A. Standard O&M Manuals.

CA Review and Approval. Prior to substantial completion, the CA shall review the O&M manuals, documentation and redline as-builts for systems that were commissioned to verify compliance with the Specifications. The CA will communicate deficiencies in the manuals to the PM.

B. Commissioning Record in O&M Manuals.

The CA is responsible to compile, organize and index all commissioning data by equipment into labeled, indexed and tabbed, three-ring binders and deliver it to the PM. Three copies of the manuals will be provided. The manuals shall include the Commissioning Plan, Final Commissioning Report, System Type, Startup and Pre-functional checklists, Functional performance tests, trending and analysis, approvals and corrections, training plan, records, and approvals.

2.7 Training of Owner Personnel

A. The GC shall be responsible for training coordination and scheduling and for ensuring that training is completed.

B. The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.

1. The specific training requirements of Owner personnel by Subs and vendors is specified in Division 15 and 16.
2. For the primary HVAC equipment, the Controls Contractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.

2.8 Deferred Testing

A. Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.

23 09 00 Instrumentation and Control for HVAC

PART 1 - GENERAL

1.1 Commissioning

B. The project will have selected building systems commissioned. The equipment and systems to be commissioned are specified in Section 23 08 00. The commissioning process and contractor responsibilities are described in Section 23 08 00.

1.2 Related Sections

1. 01 31 00 Project Management and Coordination
2. 01 33 00 Submittal Procedures
3. 01 75 00 Starting and Adjusting
4. 01 77 00 Closeout Procedures
5. 01 78 00 Closeout Submittals
6. 01 78 23 Operation and Maintenance Data

7. 01 79 00 Demonstration and Training
8. 01 91 00 Commissioning
9. 23 05 93 Testing, Adjusting and Balancing for HVAC
10. 23 08 00 Commissioning of HVAC

1.3 Submittals

Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:

a. An overview narrative of the system generally describing its purpose, components and function.
b. All interactions and interlocks with other systems.
c. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
d. Written sequences of control for packaged controlled equipment.
e. Sequences of control for the following modes of operation: Start-up, Warm-up, Cool-down, Normal occupied, Unoccupied, and Shutdown.
f. Capacity control sequences and equipment staging.
g. Temperature and pressure control: setbacks, setups, resets, etc.
h. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
i. Effects of power or equipment failure with all standby component functions.
j. Sequences for all alarms and emergency shut downs.
k. Seasonal operational differences and recommendations.

Control Drawings Submittal

a. The control drawings shall have a key to all abbreviations.
b. The control drawings shall contain graphic schematic depictions of the systems and each component.
c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

d. Provide a full points list with at least the following included for each point:
    1) Controlled system
    2) Point abbreviation
    3) Point description
    4) Display unit
    5) Control point or setpoint (Yes / No)
    6) Monitoring point (Yes / No)
    7) Intermediate point (Yes / No)
    8) Calculated point (Yes / No)

An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O&M manual submittal.

The controls contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing. Provide a signed and dated certification to the CA and PM upon completion of the control system checkout.

Exhibit 1: Focused Design Development Review Elements

The following items will be reviewed by the commissioning authority.

Design Area	Review Description
Energy Efficiency	General efficiency of building shell, building layout, HVAC system types, lighting system type, etc.
Operations and Maintenance (O&M).	How building O&M can be made easier (accessibility and system control, etc.)
Indoor Environmental Quality (IEQ)	How thermal, visual, acoustical comfort or air quality can be improved (Refer to Exhibit 4 for IAQ).
Functionality for Tenants	How the design can be changed to improve functionality for the occupants
Environmental Sustainability	How the building materials and systems and landscaping can create less of an impact on the environment

Exhibit 2: Focused 50% and 95% Design Review Elements

The commissioning authority will perform a review at 50% and 95% design construction documents completion comprised of the following items:

Design Area	Review Description
Commissioning facilitation	Input regarding making the building easier to commission (see Exhibit 3).
Component energy efficiency	Review for adequacy of the efficiency of bldg. shell components, HVAC systems and lighting systems.
Control system & control strategies	Review HVAC, lighting, fire control, emergency power, strategies and sequences of operation for adequacy and efficiency.
Operations and maintenance	Review for effects of specified systems and layout toward facilitating O&M (equipment accessibility, system control, etc.).
Indoor environmental quality	Review to ensure that systems relating to thermal, visual, acoustical, air quality comfort, air distribution are in accordance with the design intent. (Refer to Exhibit 4 for IAQ).
Environmental sustainability	Review to ensure that the building materials, landscaping, use of water resources, and waste management are in accordance with the design intent.
Functionality for occupants	Review to ensure that the design meets the functionality needs of the occupants.
Life cycle costs	Perform a quantitative life cycle assessment of the primary competing systems relative to energy efficiency, O&M, IAQ.
O&M documentation	Verify that building O&M plan and documentation requirements specified are adequate
Training	Verify that operator training requirements specified are adequate.
	Verify that bid documents adequately specify

Commissioning specifications	building commissioning for all contractors. In particular verify that there are adequate monitoring and control points specified to facilitate commissioning and O&M.
Owner's design guide or standard	Verify that the design complies with the Owner's own design standard or guideline.
Duct Pressure Testing	Verify pressure testing is in the mech duct spec section with allowable airflow leakage requirements

Exhibit 3: Commissioning Facilitation Review

One of the primary tasks for the commissioning authority is reviewing the design documents to facilitate commissioning during construction. The construction-phase commissioning process can be made easier and more effective if certain features are included in the design. The added up-front costs for most of these features can be justified because they reduce the cost of commissioning, allow for a better commissioning job and reduce the O&M costs for the building. Below is a list of some of these features. Not all are addressed in detail in the design development review. However, they should be brought to the attention of the A/E at this time, so that they can be incorporated during the construction documents phase. The review is not expected to be limited to only those issues listed below.

- Clear and rigorous design documentation, including detailed and complete sequences of operation.
- An HVAC fire and emergency power response matrix that lists all equipment and components (air handlers, dampers, valves, etc.) with their status and action during a fire alarm and under emergency power.
- Access for reading gages, entering doors and panels, observing and replacing filters, coils, etc.
- Required isolation valves, dampers, interlocks, piping, etc. to allow for manual overrides, simulating failures, seasons and other testing conditions.
- Sufficient monitoring points in the building automation system (BAS), even beyond that necessary to control the systems, to facilitate performance verification and O&M.
- Adequate trending and reporting features in the BAS.
- Pressure and temperature (P/T) plugs close to controlling sensors for verifying their calibration.
- Pressure gages, thermometers and flow meters in strategic areas to facilitate verifying system performance and ongoing O&M.
- Pressure and temperature (P/T) plugs at less critical areas or on smaller equipment where gages and thermometers would be over-kill.
- Specification of the location and criteria for the VAV duct static pressure sensor and chilled water differential pressure sensor.
- Adequate balancing valves, flow metering and control stations and control system functions to facilitate and verify reliable test and balance.
- Uniform inlet connection requirements to VAV terminal boxes.
- Clear and complete commissioning specifications for the construction phase.

- Complete O&M documentation requirements in the specifications.
- Complete training requirements in the specifications.
- Review entire document and building information management plan from design through construction and turnover to ensure adequacy and compliance with the owner's program.

Exhibit 4: Commissioning for Indoor Air Quality Review Checklist

Program Phase

Document the results from each of the following tasks:

1. Determine indoor air quality requirements in accordance with the initial design intent of the owner's needs. Codes, standards: *ASHRAE Standard 62-1989, Ventilation for Acceptable Air Quality* and *Standard 55-1992 Thermal Environmental Conditions for Human Occupancy*.
2. Identify the sources of outdoor pollutants in the vicinity of the building site: general ambient air quality, exhaust systems, nearby cooling towers, smoke stacks, and existing or proposed parking garages, etc.
3. Review expected occupant activity, density and locations where special attention is needed: kitchens and break rooms, smoking lounges, photocopy and print rooms, janitorial rooms, labs, material storage rooms, and conference rooms, etc. Review the need for exhaust systems or increased supply air capacity for each area, etc.

Design Development and Construction Documents Phase

Document the results from each of the following tasks:

1. Ensure that the indoor air quality objectives established in the programming phase are included in the design and are well documented in the design intent.
2. Establish the outdoor air intake requirements for each area of the building.
3. Establish procedures for verifying and documenting ventilation rates in each area.
4. Establish air flow rates for needed exhaust systems, including spot pollutant source removal.
5. Determine how adequate ventilation rates will be maintained during all occupied modes of operations, particularly during VAV terminal box turn-down.
6. Review air intakes and exhausts for short-circuiting.
7. Review exterior pollution sources such as garages, loading docks, and cooling towers.
8. Review the impact of the office partitions configurations with respect to ventilation effectiveness.
9. Review choice of filtration type and design, materials, and location.
10. Review HVAC material specifications and application regarding potential for airflow erosion, corrosion and microbial contamination (HVAC insulation materials, etc.).
11. Review air supply system components to ensure control and minimization of the presence of free water and to minimize microbial contamination (condensate trays, humidifiers, water baffles, mist eliminators and cooling towers).

12. Verify the suitability of access doors and inspection ports to all chambers and components of air handling system plenums. Verify that proper cleaning of both sides of coils, condensate pans and/or humidifier reservoirs can be accomplished through the doors.
13. Optional: Examine manufacturer's safety data sheets (MSDS) for products specified in contract documents that may be suspected contributors to indoor pollutants (carpets, flooring, fabrics, adhesives, wall coverings, partitions, and ceilings; insulating and fire-proofing materials; sealants on walls and floors; use of preservatives, paints, varnishes, and other finish materials).
14. Obtain manufacturer's data on curing, drying and airing procedures to minimize emission rates.
15. Verify that the specifications specify proper methods and conditions for operating the HVAC system prior to full control and occupancy, to minimize dirt and unwanted moisture entering the duct work, coils, building cavities and any occupied portions of the building.

Note:
Indoor air quality (IAQ) commissioning does not ensure that indoor air quality will be adequate or without deficiency at building turnover or during occupancy, unless the owner has specifically specified that actual air quality testing be performed. Commissioning for indoor air quality entails performing tasks that minimize the potential for IAQ problems, but it does not eliminate their possibility.

The primary source for this checklist was Annex C in *ASHRAE Guideline 1-1989R The HVAC Commissioning Process,* Public Review Draft, 1996.

Project / Facility Name

Functional Performance Test

Title:		Single-Zone AHU/HW			
Tag:		SZU-5			
Pass	**Fail**	**Event #**	**Description of Event Testing**	**Expected and/or Actual Results**	**Remarks**
		1a	Optimum Start, Heating: This will be verified during short-term monitoring	Unit starts maximum 2 hours before occupied schedule start to achieve an average zone temperature of 68F at the beginning of the occupied schedule start time. System begins occupied cycle when ZAT = 68F.	
		1b	Optimum Start, Cooling This will be verified during short-term monitoring.	Cool down cycle begins if HWS is disabled. Starts maximum of 2 hours before occupied start to achieve an avg zone temperature of 74F at the beginning of the occupied start time.System begins occupied cycle when ZAT = 74F.	
		1c	Begin occupied mode	Toilet exhaust runs continually	No mention of TE in sequence, but shown in drawing.
		2a	Occupied Mode; Override OAT to be 2F less than RAT.	Economizer mode enabled. MAD modulates to maintain mixed air temperature.	
		2b	Override OAT to = RAT	Economizer disabled. MAD returns to minimum position of 10%.	
		2c	Override MAT to be less than 45F.	Alarm is generated. Outside air damper closes until MAT > 48F.	
		3a	Override CO2 differential to be >700 ppm.	OA increases to maintain 700ppm differential.	
		3b	In CO2 monitoring mode, begin economizer cycle.	Economizer cycle overrides CO2 control.	
		3c	In CO2 control, begin unoccupied mode.	CO2 control overridden. OA damper closes.	
		3d	In CO2 control, trip MAT alarm.	CO2 control halts. Dampers go to full return.	
		4	In occupied mode, begin heating mode (HWS is enabled)	HW valve modulates to maintain setpoint.	
		5a	Change in occupancy to unoccupied (night setback inactive) will be verified thru short-term monitoring	Supply fan shuts off. Mixed air dampers go to full return. Hot water control valve modulates to maintain 50F HD temperature [this isn't in sequence, but shouldn't it?].	
		5b	Unoccupied mode; override 6-hr timer to ON.	System forced into occupied mode.	
		6a	Change in occupancy to unoccupied (night setback active). Override space temperatures to < 63F.	Occupied sequence begins. Mixed air dampers stay at full return. Should exhaust fan turn off? No mention of this in sequence.	

Project / Facility Name

Functional Performance Test

Title:		Single-Zone AHU/HW			
Tag:		SZU-5			
Pass	**Fail**	**Event #**	**Description of Event Testing**	**Expected and/or Actual Results**	**Remarks**
		6b	Change in occupancy to unoccupied (night setback active). Override space temperatures to show >65F.	Occupied sequence ends. System still in night setback mode.	
		7a	Disable fire call out. Activate smoke detector.	Unit is disabled.	
		7b	Activate low limit thermostat.	Upon low limit, mixed air dampers go to full return and hot water control valve goes full open.	
		7c	Activate fan failure alarm [command ON and status OFF or vice versa].	Alarm generated (15-min. delay). MADs go to full return and HW valve goes to full open.	
		7d	Override MAT to <37F	Alarm generated. MADs go to full return and HW valve goes to full open. Alarm stays until MAT >41F (15-min delay).	
		7e	System in occupied mode. Override DAT > 120F.	Alarm generated (15-min. delay). Alarm inhibited when system is off.	
		7f	System in occupied mode. Override DAT <45F.	Alarm generated (15-min. delay). Alarm inhibited when system is off.	
		7g	System in occupied mode. Override RAT > 85F.	Alarm generated (15-min. delay). Alarm inhibited when system is off.	
		7h	System in occupied mode. Override RAT < 55F.	Alarm generated (15-min. delay). Alarm inhibited when system is off.	
		7i	System in occupied mode. Override ZAT > 85F.	Alarm generated (15-min. delay). Alarm inhibited when system is off.	
		7j	System in occupied mode. Override ZAT < 55F.	Alarm generated (15-min. delay).	