CALIFORNIA
ENERGY
COMMISSION

REFERENCE SPECIFICATIONS FOR RESOURCE AND ENERGY EFFICIENCY

Reference Specifications for Energy and Resource Efficiency

Division 15 Sample Functional Tests

Division 15 Pre-Functional Test Data Sheets

TECHNICAL REPORT

March 2004
500-04-015-A1

Arnold Schwarzenegger, *Governor*

Prepared By:
Eley Associates
Erik Kolderup
142 Minna Street
San Francisco, CA 94105
Contract No. 500-98-027

Prepared For:

California Energy Commission

Chris Scruton
Project Manager

Nancy Jenkins
PIER Buildings Program Manager

Terry Surles
PIER Program Director

Robert L. Therkelsen
Executive Director

Acknowledgements

- **Eley Associates**: Erik Kolderup, Aditi Raychoudhury, Larry Ayers, Kimberly Got, and Kyra Epstein
  (As of February 2, 2004, Eley Associates is part of Architectural Energy Corporation)
- **Simon Martin-Vegue Winkelstein Moris**: Anthony Bernheim and Marian Keeler
- **Taylor Engineering**: Steve Taylor, Mark Hydeman, and Jeff Stein
- **AfterImage**: Brian Liebel
- **John Raeber**, FAIA, FCSI, CCS
- **Catherine Cooper Market Research**
- **TMT Associates**: Thomas Tolen

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 (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

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

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

What follows is an attachment to the final report for the Reference Specifications for Resource and Energy Efficiency project, Contract Number 500-98-027, conducted by Eley Associates. This project contributes to the PIER Building End-Use Energy Efficiency program.

This attachment, "Reference Specifications for Energy and Resource Efficiency" (Attachment A-1), provides supplemental information to the project's final report and includes the following documents:

- *Reference Specifications for Energy and Resource Efficiency*
- *Division 15 Sample Functional Tests*
- *Division 15 Pre-Functional Test Data Sheets*

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200.

Abstract

This attachment is a set of documents produced by the Reference Specifications for Energy and Resource Efficiency project, funded by the California Energy Commission's Public Interest Energy Research (PIER) Program.

Architects, engineers, and lighting designers generally wish to include energy efficient elements in their designs, but they don't have the information readily available. The goal of this research project was to provide a resource that is directly useful to building designers by developing a set of reference specifications for users to select from and insert into their construction documents. Specifications were developed to cover energy efficiency, indoor air quality, and resource efficiency topics.

This attachment, "Reference Specifications for Resource and Energy Efficiency" (Attachment A-1), provides supplemental information to the project's final report and includes the following documents:

Reference Specifications for Energy and Resource Efficiency
The complete reference specifications, comprised of Divisions 1-12 and 15-17.

Division 15 Sample Functional Tests
Contains sample functional tests referenced in Division 15.

Division 15 Pre-Functional Test Data Sheets
Contains pre-functional test data sheets referenced in Division 15.

CONTENTS

CONTENTS I
DISCLAIMER II
SECTION 01350 - SPECIAL ENVIRONMENTAL REQUIREMENTS 1
SECTION 01350 - SPECIAL ENVIRONMENTAL REQUIREMENTS NOTES 25
SECTION 01565 - SITE WASTE MANAGEMENT PROGRAM 28
SECTION 01565 - SITE WASTE MANAGEMENT PROGRAM NOTES 31
SECTION 01810 - COMMISSIONING 32
SECTION 01810 - COMMISSIONING - NOTES 39
SECTION 02848- PARKING BUMPERS 40
SECTION 02848 - PARKING BUMPERS NOTES 42
SECTION 02870 - SITE FURNISHINGS 43
SECTION 02870 - SITE FURNISHINGS NOTES 44
SECTION 03050 - BASIC CONCRETE MATERIALS AND METHODS 45
SECTION 03050 - BASIC CONCRETE MATERIALS AND METHODS NOTES 46
SECTION 03300- CAST-IN-PLACE CONCRETE 47
SECTION 03300 - CAST-IN-PLACE CONCRETE NOTES 48
SECTION 03400 - PRECAST PANELS WITH STONE VENEER OR TILE 49
SECTION 03400 - PRECAST PANELS WITH STONE VENEER OR TILE NOTES 50
SECTION 04050 - BASIC MASONRY MATERIALS AND METHODS 51
SECTION 04050 - BASIC MASONRY MATERIALS AND METHODS NOTES 52
SECTION 04400 - STONE 53
SECTION 04400 - STONE NOTES 54
SECTION 05050 - BASIC METAL MATERIALS AND METHODS 55
SECTION 05050 - BASIC METAL MATERIALS AND METHODS NOTES 56
SECTION 05100 - STRUCTURAL STEEL 57
SECTION 05100 - STRUCTURAL STEEL NOTES 58
SECTION 05300 - METAL DECK 59
SECTION 05300 - METAL DECK NOTES 60
SECTION 06060 - WOOD MATERIALS 61
SECTION 06060 - WOOD MATERIALS NOTES 62
SECTION 06065 - PLASTIC MATERIALS 63
SECTION 06065 - PLASTIC MATERIALS NOTES 64
SECTION 06070 - WOOD TREATMENT 65
SECTION 06070 - WOOD TREATMENT NOTES 67
SECTION 06080 - FACTORY-APPLIED WOOD COATINGS 68
SECTION 06100 - ROUGH CARPENTRY 69
SECTION 06100 - ROUGH CARPENTRY NOTES 71
SECTION 06200 - FINISH CARPENTRY 72
SECTION 06200 - FINISH CARPENTRY NOTES 74
SECTION 06400 - INTERIOR ARCHITECTURAL WOODWORK 75
SECTION 06400 - INTERIOR ARCHITECTURAL WOODWORK NOTES 77

DISCLAIMER

The authors have tried to make the information in this document as accurate and useful as possible. However, they make no warranty, express or implied, and assume no legal liability for the information in this report. References to specific manufacturers or products are provided for the convenience of the reader and shall not be considered endorsements.

These specifications were prepared as a 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 warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

SECTION 01350 - SPECIAL ENVIRONMENTAL REQUIREMENTS

(Note 1)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes Special Environmental Requirements: Work includes special environmental, sustainable, and "green" building practices related to energy conservation and efficiency, indoor air quality, and resource efficiency, including the following:

1. Special Requirements:
    a. Require practices to ensure healthy indoor air quality in final Project.
    b. Maximize use of durable products.
    c. Maximize use of products easy to maintain, repair, and that can be cleaned using non-toxic substances.
    d. Maximize recycled content in materials, products, and systems.
    e. Require use of wood from certified sustainably harvested by the Forest Stewardship Council (FSC)..
    f. Maximize use of reusable and recyclable packaging.
    g. Maximize use of products with low embodied energy (production, manufacturing, and transportation).
2. Construction team is required to comply with sustainable building practices during construction and when considering materials for substitutions. Refer to Article 1.2 – Design Requirements.

B. Related Requirements:
Refer to Specification sections for special environmental requirements for specific products.

1. Section 01565: Site Waste Management Program.
2. Section 01600: Product Requirements.
3. Section 01810: Building Commissioning.
4. Section 01820: System Demonstration.

1.2 DESIGN REQUIREMENTS *(NOTE 2)*

A. General: Owner has established with design team general environmental goals for design and for construction of Project; Contractor, subcontractors, suppliers, and manufacturers (construction team) are encouraged to participate where possible to realize Owner's environmental goals.

1. Intent is for environmental goals to be achieved in manner that ultimately provides safe and healthy environment for building occupants with minimal impact on local, regional and global environment.
2. Contract Documents are not intended to limit alternative means of achieving environmental goals.
    a. Suggestions from construction team for implementing goals are encouraged.
    b. Team approach is encouraged.

B. Environmental Goals:
   1. Refer to specific Specifications sections for more detailed construction requirements related to specific materials and systems.
      a. Energy Efficiency (Operations Throughout Project Life): Materials and systems are intended to maximize energy efficiency for operation of Project throughout service life (substantial completion to ultimate disposition – reuse, recycling, or demolition).
      b. Indoor Environmental and Air Quality: Materials are selected and processes specified, such as preconditioning and temporary ventilation, to maximize healthy indoor air quality. Cleaning, surface coating, and renewal or replacement of interior materials should be feasible with lowest practical use of toxic, irritating, or odorous compounds. Ventilation system design, construction, and commissioning ensure adequate outside air supply under all anticipated conditions of use. Documentation of system design assumptions is included in Project Manuals to enable building operators and management to use and modify the system as required to provide continued assurance of indoor air quality. Additionally, materials are selected to provide appropriate indoor environmental qualities such as good acoustics and lighting.
      c. Resource Efficiency (Project Construction): Materials and systems are to maximize environmentally-benign construction techniques, including construction waste recycling, reusable delivery packaging, and reusability of selected materials.

C. Energy Conservation: Maximize energy conservation strategies in order to reduce life-cycle energy requirements.
   1. Reduce undesirable heat gain and heat loss through exterior envelope.
   2. Use daylight as the primary lighting source and supplement with integrated and energy-efficient electrical lighting systems.
   3. Choose equipment with high-end energy performance characteristics, including lighting, HVAC systems, appliances, and office equipment.
   4. Where appropriate, use thermal storage strategies such as thermal mass of building or ground to minimize total energy consumption.
   5. Design mechanical systems for efficient operation throughout the typical operating range, from minimum to peak load.

D. Sustainable Site Planning and Landscape:
   1. Maximize erosion and sedimentation control.
   2. Minimize site disturbance.
   3. Maximize planted areas.
   4. Reduce heat islands.
   5. Where possible, reduce or eliminate light pollution from site lighting. *(Note 3)*
   6. Reduce or eliminate use of pesticides.
   7. Rely on indigenous, dry or xeriscape planting. Maintain existing planting on site to reduce costs.
   8. Implement seasonal plant and soil maintenance schedule to maintain healthy soil and landscaping.
   9. Maximize stormwater runoff.

10. Reduce water use with water efficient irrigation systems and local vegetation.

E. Durable Materials:
   1. Select materials with longest useful service life.
   2. Select materials that deteriorate minimally under installed conditions, exposures, and uses.
   3. Select materials with surfaces that require minimal or no refinishing or resurfacing.
   4. Select materials with protective coating requirements that do not involve frequent application of toxic or odorous components for materials that require surface renewal or protection
   5. Select materials that can be re-used after their service life in this building.
   6. Select materials that can be recycled at the end of their useful lives for materials that cannot be re-used.

F. Resource Efficient Materials: Use resource efficient materials; consider energy use over life cycle of material including harvesting, mining, manufacturing, transport, installation, use, operations, recycling and disposal.
   1. Where possible and allowable by the Agency and Code with jurisdiction over the project, re-use existing building materials to extent feasible within design concept expressed in Contract Documents.
   2. Select materials that efficiently use resources such as energy, water, and component materials.
   3. Use construction practices such as material reduction and dimensional planning that maximize efficient use of resources and materials.
   4. Provide materials that utilize recycled content to maximum degree possible without being detrimental to product performance or indoor air quality.
   5. Where possible and feasible, provide for non-destructive removal and re-use of materials after their service life in this building.
   6. Select materials that use less embodied energy to manufacture.
      a. Exceptions might include materials that result in net energy conservation during their useful life in building and building’s life cycle.
   7. Select materials that conserve energy during building operations.
   8. Where possible, select materials harvested and manufactured regionally, within a 500-mile radius of the project site.

G. Scarce, Irreplaceable, and Endangered Resources:
   1. Select materials from abundant resources.
      a. For natural resources, determine abundance based on ratio of removal rate from existing stocks to natural replacement/renewal rate, where this information is available.
      b. For mineral resources, determine abundance based on ratio of removal rate from terrestrial storage minus amount re-entering commerce through recycling or resource recovery compared to total in terrestrial storage, where this information is available.
   2. Select renewable materials, and materials which can be replenished.
   3. Select materials that create minimal or no damage to natural habitats and natural environment.

4. Select materials that can be easily refinished, repaired or refurbished to extend their useful life.

H. Pollution: Select materials that generate least amount of pollution during mining, manufacturing, transport, installation, use, and disposal.

1. Avoid materials that emit greenhouse gases
2. Avoid materials that require energy intensive extraction, manufacturing, processing, transport, installation, maintenance, or removal.
3. Avoid materials that contain ozone-depleting chemicals (e.g. CFCs or HCFCs).
4. Avoid materials that emit potentially harmful volatile organic chemicals (VOCs), as described in Article 2.2.
5. Employ construction practices that minimize dust production and combustion by-products.
6. Avoid materials that can leach harmful chemicals into ground water; do not allow potentially harmful chemicals to enter sewers or storm drains.
7. Protect soil against erosion and topsoil depletion.
8. Minimize noise generation during construction; screen mechanical equipment to block noise.
9. Select materials that can be reused or recycled and materials with significant percentage of recycled content; conform with or exceed specified Project recycled content percentages for individual materials; avoid materials difficult to recycle.
10. Protect natural habitats; restore natural habitats where feasible within scope of Project.

I. Wood Products:

1. Use woods from Forest Stewardship Council (FSC) accredited certified sustainably harvested sources.
2. Composite wood products with high-recycled content, which meet the indoor air quality data requirements, are acceptable. *(Note 4)*

J. Water Efficiency:

1. Reduce the use of municipally supplied potable water.
2. Reduce dependence on municipal storm water system for plumbing fixtures and irrigation. Eliminate irrigation or use micro-irrigation. Use no moisture sensors or clock timers on irrigation systems.
3. Maintain natural aquifer conditions.
4. Consider roofwater or groundwater collection system.
5. Consider graywater collection system for irrigation systems.
6. Commission irrigation, graywater, roofwater collection systems. Provide measurement and verification for these systems. Train maintenance staff on performance of all water collection and distribution systems.

1.3 SUBMITTALS

A. Resource Efficient Product Data:

1. Environmental Issues Data: Submit following information, including manufacturer's certifications, verifying information, and test data, where Specifications sections require data relating to environmental issues including but

not limited to:

a. Project Recyclability: Submit information to assist Owner and Contractor in recycling materials involved in shipping, handling, and delivery, and for temporary materials necessary for installation of products.

b. Recycled Content: Submit information regarding product post industrial recycled and post consumer recycled content.

   i. Use the “Recycled Content Certification Form”, attached as Appendix A to this Section, signed by a corporate office holder (i.e. Chairman of the Board, President, Vice President, Secretary, or similar position of authority). *(Note 5)*

c. Product Recyclability: Submit information regarding product and product’s component’s recyclability including potential sources accepting recyclable materials.

d. Provide certification for all wood products provided by a Forest Stewardship Council (FSC) accredited certifier.

e. Provide final certification of well-managed* forest of origin to provide final documentation of certified sustainably harvested status: Acceptable wood “certified sustainably harvested” certifications shall include:

   i. Wood suppliers’ certificate issued by one of the Forest Stewardship Council-accredited certifying agencies, such as Smart wood (800-434-5491) or Forest Conservation Program (510-832-1415);

   ii. Suppliers’ invoice detailing the quantities of certified wood products for project;

   iii. Letter from one of a certifying agency corroborating that the products on the wood supplier’s invoice originate from certified well-managed forests. *(Note 6)*

B. Indoor Air Quality (IAQ) Data: *(Note 7)*

1. Environmental Issues: Submit emission test data produced by acceptable testing laboratory listed in Quality Assurance Article for materials as required in each specific Specification section.

   a. Laboratory reports shall contain emissions test data on VOCs including total VOCs (TVOC), specific individual VOCs, formaldehyde and other aldehydes as described in this Specification Section.

   b. In special cases it may be necessary to identify other specific chemicals for listing based on known quantity present or on known odor, irritation or toxicity.

   c. Identify all VOCs emitted by each material as required in these Specifications.

   d. Specific test conditions and requirements are set forth in this Section. For required tests, submit documentation of sample acquisition, handling, and test specimen preparation, as well as test conditions, methods, and procedures. The tests consist of a ten-day conditioning period followed by a 96-h test period.

      i. Samples collected during the test period at 24, 48, and 96 hours shall be analyzed for TVOC and formaldehyde. *(Note 8)*

ii. VOC samples collected at 96 hours shall be identified and quantified for all compounds that are Chemicals of Concern on lists in Article 2.

2. Cleaning and Maintenance Products: Provide data on manufacturers' recommended maintenance, cleaning, refinishing and disposal procedures for materials and products. These procedures are for final Contractor cleaning of the project prior to substantial completion and for provided materials and products as required by the specific specification sections.
   a. Where chemical products are recommended for these procedures, provide documentation to indicate that no component present in the cleaning product at more than 1% of the total mass of the cleaning product is a carcinogen or reproductive toxicant as defined in the lists in this specification section.
   b. For purposes of reporting, identification of product VOC contents shall not be limited to those regulated under Clean Air Act (CAA) but shall also include compounds exempted from the CAA definition and listing of VOCs.
   c. California EPA and local air district definitions of VOCs based on CAA are not sufficient as they exempt compounds based on non-reactivity for outdoor air pollution control but still important for indoor air quality.
   d. Avoid cleaning products containing alpha-pinene, d-limonene or other unsaturated carbon double bond alkenes due to chemical reactions with ozone to form aldehydes, acidic aerosols, and ultra fine particulate matter in indoor air. For State buildings, DGS has published specifications for Environmentally Preferable Janitorial Chemicals and a list of cleaning/maintenance products meeting these specifications. Both are available on the internet at: http://www.ciwmb.ca.gov/greenbuilding/Specs/Janitorial.doc and http://www.resd.dgs.ca.gov/BPM/lists.htm . *(Note 9)*

C. Certificates:
1. Environmental Issues Certifications:
   a. Submit documentation certifying accuracy of post-industrial and post-consumer recycled content, and recyclability.
   b. Prior to Final Completion, submit certificate signed by corporate office holder (i.e. Chairman of the Board, President, Vice President, Secretary, or similar position of authority) of contractor, subcontractor, supplier, vendor, installer or manufacturer, provided they are primarily responsible for manufacture of product, indicating:
      i. Post-industrial and post-consumer recycled content of materials installed are same as those required by Project requirements.
      ii. Product recyclability of materials installed are same as those required by Project requirements.
      iii. Indoor air quality requirements. Certification shall state products and materials provided are essentially same, and contain essentially same components as products and materials tested.
   c. Comply with requirements specified in Section 01770 – Closeout Procedures.

D. Closeout Submittals: Submit data relating to environmental issues.
1. Submit environmental product certifications, in two forms:
   a. Two CD-ROMs organized by CSI 16 Division Format.

b. Four three-ring binders organized by CSI 16 Division Format with Table of Contents and with dividers for each division.

1.4 QUALITY ASSURANCE

A. Environmental Project Management and Coordination: Contractor to identify one person on Contractor's staff to be responsible for environmental issues compliance and coordination.

1. Experience: Environmental project manager to have experience relating to sustainable building construction.
2. Responsibilities: Carefully review Contract Documents for environmental issues, coordinate work of trades, subcontractors, and suppliers; instruct workers relating to environmental issues; and oversee Project Environmental Goals.
3. Meetings: Discuss Environmental Goals at following meetings.
    a. Pre-construction meeting.
    b. Pre-installation meetings.
    c. Regularly scheduled job-site meetings.
    d. Special sustainability issues meetings.

B. Environmental Issues Criteria: Comply with requirements listed in various Specification sections.

C. Acceptable Indoor Air Emissions Testing Laboratories: *(Note 10)*

1. Berkeley Analytical Associates; 815 Harbour Way South, Suite 6, Richmond, California 94804; telephone 510.236.2325; fax 510.236.2335; e-mail berkeleyanalytical@ att.net .
2. Air Quality Sciences, Inc.; 1337 Capital Circle, Atlanta, Georgia 30067; telephone 770.933.0638; fax 770.933.0641; e-mail aqs@mindspring.com.
3. Other Laboratories:
    a. Selection of testing laboratories shall include assessment of prior experience in conducting indoor source emissions tests.
    b. Many laboratories participate in and are certified by American Industrial Hygiene Association laboratory accreditation program. http://www.aiha.org/lists.html.
        i. These laboratories are accredited to do analysis for hazards at levels of concern for industrial workplaces and not necessarily accredited, organized, or able to perform analysis for chemicals and particulate matter at concentrations of concern for indoor air.
    c. The proposed laboratory shall be an independent company or organization not related to manufacturer of product to be tested.
    d. Submit documentation on proposed laboratory for review and approval by Owner.

D. Indoor Air Emissions Tests: *(Note 11)*

1. Provide environmental chamber test data from tests based on ASTM Standard D5116-97, Guide for Small Scale Environmental Chamber Determination of Organic Emissions from Indoor Materials/Products. (Refer to ASTM, Annual Book of Standards, Volume 11.03. West Conshohocken, PA: American Society for Testing and Materials. http://www.astm.org.)

2. Tests shall be conducted according to guidance contained in ASTM Standard D5116-97 on material test specimens pre-conditioned in clean air prior to testing.
   a. Review test specimen collection, documentation, collection, preparation and shipping procedures with testing laboratory prior to preparing and shipping sample.
   b. Test specimens shall be packaged in the normal manner at the factory and shipped directly to testing laboratory by the manufacturer. For materials that are not packaged in convenient consumer units, alternate procedures to preserve the chemical integrity of the specimen are required. Obtain test laboratory procedure sheet covering the handling and shipping of materials. If such information is not provided by the laboratory, then wrap the specimen in a manner that will eliminate direct contact with air or packaging materials other than an inert air barrier such as foil or laboratory grade plastic sheet wrapping material.
   c. Conditioning: Condition all test specimens for ten days in clean air. Clean air should be free from the Chemicals of Concern listed in Article 2. Hold in clean vessels approximately the size of the test chambers and ventilated at the same air flow rate to be used in the test period. Suspend or place specimens on wire racks so that air freely circulates around all sides during the conditioning period. The air temperature and relative humidity during the conditioning period shall be 23±2ºC and 50±10% RH. Otherwise, the material must be held in an environmental chamber for the entire period.
   d. For wet-applied products and material assemblies, a realistic test specimen shall be prepared using the substrate material on which it will be applied in the building. Alternately, it may be necessary to use a substrate material that closely simulates the actual building substrate.
   e. For material assemblies (e.g., floor and wall systems where the finish material is placed over a substrate, either with or without the use of adhesives), individual components of the assembly system shall be tested separately. If all components meet the emissions criteria established herein, no further testing shall be required. For assemblies where one component, such as a floor or wall covering adhesive, does not meet the criteria, the assembled system may be tested with specimen preparation following the manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturers' recommended procedures and procedures required by the project specifications, the project specifications shall be followed.
   f. Wall and other types of paints shall be tested according to the specifications for the particular material. For example, if two coats are to be applied over a primer coat, then the test specimen shall be prepared accordingly, dried between coats per manufacturer's label instructions, and tested as a complete assembly after required conditioning. The total quantity of paint applied shall be reported based on the weight of the assembly immediately before and after the application of each coat.
3. The maximum concentration for any chemical emitted at 96 hours in emissions tests shall not result in a modeled indoor air concentration greater than ½ the chronic inhalation REL concentration of California Office of Environmental Health Hazard Assessment (OEHHA) Chronic Reference Exposure Limit (REL), with the exception of formaldehyde, which is discussed separately below.

4. Formaldehyde: No single product shall contribute more than one half (½) the OEHHA staff recommended indoor air limit of 33 μg/m^3 (27 ppb) for formaldehyde. The calculated concentration of formaldehyde shall not exceed 16.5 μg/m^3. Same modeling procedure as described above shall be used for formaldehyde. This concentration limit shall apply to all building and occupancy types. *(Note 12)*
5. Construction adhesives used in Work shall comply with following requirement: no component present in adhesive at more than 1% of total mass of adhesive shall be a carcinogen or reproductive toxicant as defined in the lists in this specification section.
6. Provide calculations of modeled concentrations based on emissions test results.
   a. Calculations shall be submitted with all other documentation. This requires the calculation of emission factors based on emissions tests, then application of the emission factors, product loading factors in the building, and building parameters in a steady state mass-balance model. The model assumes zero outdoor concentrations, perfect mixing and no sink effects. Alternatively, follow procedures in ASTM D5116-97 and submit assumptions and calculations.
   b. The concentration of a compound in the building shall be calculated using the following Equation;

   $$\text{Concentration} = \frac{\text{(Emission factor) * (Loading factor)}}{\text{(Air change rate)}}$$

   For this equation, the units are: $$\mu g/m^3 = \frac{(\mu g/m^2\ hr) * (m^2/m^3)}{(h^{-1})}$$

   This can be simplified as follows:

   $$\text{Concentration} = \frac{\text{Emission rate}}{\text{Air change rate}}$$

   Note that the weekly average air change rate must be used in the calculations of concentrations of contaminants.
   c. Calculation of emission rate. Determine the emission rate by multiplying the emission factor by the amount of the material to be used in the building or air handler zone being evaluated. Multiply the emission factor by the area of the material in the building zone being assessed. Note that in some cases a length or mass may be the appropriate unit for emission factor that must then be multiplied by the length or mass of the emission source.
   d. Provide to the laboratory the total area of the zone being assessed by consulting the Contract Documents or the design engineer, to identify the total area served by the air handler that serves the area(s) within it where the material will be applied. If the material is used in multiple zones, then calculations shall be made to determine the concentration in the zone with the highest loading ratio of material to volume or material to weekly average minimum air change rate, whichever is greater.
   e. Provide to the laboratory the volume of the space served by the air handler

by multiplying the floor area by the floor-to-floor clear height (top of finish floor to bottom of structure of floor above) and multiply by 0.9 (to take account of the portion of the volume that is occupied by solid objects). This value represents the ventilated volume for purposes of the calculations required here.

f. Determine the air change rate by dividing the volume of outside air introduced into the space per hour by the ventilated volume of the space.

g. Determine the weekly average air change rate by adding the minimum design air change rate during ventilation system operating hours times the number of hours the system is operated to an assumed air change rate from infiltration during ventilation system non-operational hours times the number of hours the system is off; then divide the total by the number of hours in a week, (168). Where no values are available from the design documents, use default values as follows:

   i. Offices:

      a) Where design data are not available to calculate the weekly average air change rate, the modeling shall assume a weekly average air change rate for office buildings of 0.75 air changes per hour (ach). This “default” office air exchange rate is based on a typical weekly State office building 55 hour operating schedule and an assumed off-hours air change rate of 0.3 ach (assumed air change rate during normal operating hours is in excess of 1.0 per hour).

      b) Where specific information is available, the project specific data should be used to calculate the weekly average air change rate. A default building air change rate of 0.2 per hour during non-HVAC operations should be used.

   ii. Schools:

      a) Modeling shall assume weekly average air change rate for school buildings of 0.9 per hour. This air change rate is based on an assumed 40 hours per week of ventilation system operation at 3.0 ach and 128 hours per week of 0.2 ach through infiltration.

      b) Where specific information is available, the project specific data should be used to calculate the weekly average air change rate. A default building air exchange rate of 0.2 per hour during non-HVAC operations should be used.

   iii. Other building types or occupancy types: Use ASHRAE Standard 62-1999 default occupant densities and ventilation rates for hours of operation and 0.2 ach for non operating hours unless actual rates are known in which case the actual rates and hours of operation are to be used.

7. Environmental Chamber Testing: Indoor Air Emissions Testing Laboratories may use a range of acceptable loading ratios in order to make use of various size chambers, since these are not standardized across laboratories. Loading ratios ranging from 0.25 m^2/m^3 to 0.45 m^2/m^3 will be acceptable.

   a. For dry products, loading ratios within reasonable limits are not critical for determining emission factors; conditioning of test specimens prior to testing will reduce or eliminate differences that may occur in unconditioned samples due to evaporation-limited emissions and sink effects from adsorption of VOCs during final stages of manufacturing or while in packaging during transport to and storage at the laboratory.

b. Higher loading ratios lower expected emission factor; however, the relationship is not linear, especially at higher concentrations. Therefore, where strong formaldehyde (or other chemical) sources are known or expected to be present, loading ratios should be selected to represent a median value for the plausible range of actual building loading ratios.

c. Loading ratios used shall be included in test report.

d. Contractors shall provide to product manufacturers information on actual quantity of material to be used in Project. The product manufacturers will then forward this information to Indoor Air Emissions Testing Laboratory so loading ratios can be adjusted toward actual loading ratio of Project. However, for most low-emitting materials used in construction, actual loading ratio will not significantly affect emission rates except for strong formaldehyde sources, primarily products using urea-formaldehyde resins. *(Note 13)*

8. Sample Preparation Requirements:

a. Substrates for environmental chamber emissions tests of individual products or materials (materials tested separately):

i. Dry solid sheet type products:

a) Sheet stainless steel or aluminum tray to provide tight fit at edges and reduce emissions from edge of material specimen. If material does not fit very snugly, then use aluminized, low-emitting, clean room tape to seal edges. Dry fabric type products:

b) No substrate necessary.

ii. Wet products such as adhesives and sealers:

a) Sheet stainless steel, aluminum, or glass unless product is to be applied to gypsum board or other highly absorbent material. If substrate is a highly absorbent material, use a sample the substrate pre-conditioned for 24 hours to the temperature and humidity of the test chamber.

iii. Substrates for specific products:

a) Composite wood products (Section 06400): sample to be suspended or supported in chamber with all edges exposed and no edge masking.

b) Gypsum Board (Section 09260): no substrate (testing required ONLY if recycled content gypsum board or if water resistant types are used).

c) Acoustical Ceiling Panels (Section 09510): no substrate, sample to be suspended or supported in chamber with no edge masking.

d) Resilient flooring (Section 09650): stainless steel tray, fitted tightly so that only the upper surface is exposed. Alternately, cover back of flooring with sheet stainless steel and seal edges with low-VOC emitting aluminized clean room tape so only wear surface of flooring is exposed.

e) Carpet Tile and Broadloom Carpet (Section 09680): stainless steel tray, fitted tightly so that only the upper surface is exposed.

f) Flat and eggshell Paints (Section 09900): 5/8" gypsum board.

g) Semi-gloss paints (Section 09900): Where applied to metal, use sheet stainless steel. Where applied to gypsum board, use gypsum board conditioned as described in subsection c below.

h) Joint Sealers (Section 07900): Steel channel 0.64 cm by 0.64 cm by 25.4 cm Channel shall be filled with sealant.

b. Substrates for environmental chamber emissions tests of assemblies of products or materials (materials tested in an assembly):

i. Laminates or wood veneers applied with adhesives (Section 06400): Medium density fiberboard (MDF).

ii. Resilient flooring applied with adhesives (Section 09650): Sheet stainless steel or glass plate.

iii. Carpet Tile/Broadloom Carpet applied with adhesives and adhesives (Section 09685/Section 09680): Sheet stainless steel or glass plate.

iv. Wall Coverings applied with adhesives (Section 09700 Series): 5/8" gypsum board. Prior to preparation of the test specimen, Gypsum board substrate shall be pre-conditioned for at least 24 hours at 23 $\pm$ 2^{o}C and 50 $\pm$ 10% RH while ventilated with clean air. [Ventilation rate is not important.]

c. Protocol for Paint Testing: Preparation and handling of paint test specimen.

i. Flat and Eggshell Paints:

a) Apply paints to 5/8" thick gypsum board. Hold Gypsum board substrate for at least 24 hours at 23 $\pm$ 2^{o}C and 50 $\pm$ 10% RH while ventilated with clean air. Accurately weigh substrate just prior to painting, mask borders to avoid paint dripping on edges and leave center area for paint. Alternative approaches to protecting the edges are acceptable and shall be reported if used.

b) Apply paint using standardized roller procedure that simulates application of paint in building. For most wall paint applications use a 4" wide 3/8" nap roller intended for smooth surfaces.

c) Stir paint in container and transfer 100 mL of paint to heavy-duty aluminum foil disposable tray.

d) Saturate roller cover with paint by running back and forth in tray.

e) Apply paint to substrate using four strokes, two in vertical direction and two in horizontal direction, so entire area is uniformly covered.

f) Remove tape from substrate and re-weigh substrate.

g) Difference in weight determines amount of applied paint and coverage in grams of wet paint per square meter of substrate surface.

h) Place substrate on 6" by 6" piece of sheet stainless steel to cover entirely the back surface. Attach substrate to stainless steel with strips of low VOC aluminized clean room tape so only painted surface is exposed. For a blank specimen, similarly prepare an unpainted piece of gypsum. Alternate procedures to cover unpainted surfaces of gypsum board may be used and must be adequately described in the laboratory report if used.

i) Place sample in conditioning environment immediately and hold for ten days.

j) Where multiple coats, which may include primer, are being tested, apply paints and follow manufacturers' instructions for drying time between coats. Report weight of test specimen prior to and after each coat of paint is applied. Hold specimen in conditioning environment between coats. The ten-day conditioning period begins after application of final coat. Apply semi-gloss paint to clean steel sheet following same procedure as above for "flat and eggshell paints." No tape should be used. Sheet should be weighed immediately before and after painting.

9. Chemical Analyses:
   a. VOC Analysis: Make multi-point calibrations using pure compounds whenever such compounds are available from commercial suppliers (such as Aldrich Chemical Company, Sigma Aldrich). Quantitative analyses performed using surrogate compounds shall be indicated in reported test results. Identify EPA and ASTM standard methods and practices, and testing laboratory calibration procedures, which should include a calibration at least once every three (3) months.
   b. Formaldehyde and Acetaldehyde Analysis: Formaldehyde and Acetaldehyde analysis shall be performed following ASTM Standard D 5197 "Standard Test Method for Formaldehyde and other Carbonyl Compounds in Air (Active Sampler Methodology)"
10. Reporting Requirements: In addition to reporting requirement stated elsewhere in Specifications, reports shall include: (a) all compounds emitted from sample that are on the most recent Chronic Reference Exposure Level list as published by the California Office of Environmental Health Hazard Assessment and listed on their website at http://www.oehha.org/air/chronic_rels/allChrels.html , (b) all compounds on the California Proposition 65 list, and (c) all compounds on the California Toxic Air Contaminant list. In addition, the ten most abundant compounds shall be reported separately if not listed on any of these lists. For these compounds, report following::
    a. measured chamber concentrations at each required time point.
    b. calculated emission factors.
    c. calculated building concentrations and assumptions used to make calculation. *(Note 14)*

E. State Agency Buy Recycled Campaign (SABRC) Recycled Content: Implement the SABRC recycled-content goals for specific building products, including but not limited to: *(Note 15)*
   1. Paper products;
   2. Glass products (windows, glazing, fiberglass, tile, construction blocks, loose-grain abrasives);
   3. Plastic products (carpet, plastic lumber, furniture made from plastic, fencing, parking bumpers, toilet partitions, entry mats, signage, sheet plastic and other plastic-containing building products);
   4. Solvents;
   5. Tire-derived products (entry-mats, resilient flooring, wheelchair and other ramps,

playground surfacing, parking bumpers, speed bumps, tree ties, road surfacing);

6. Steel products (structural steel, steel framing, architectural metal, reinforcing bars, sheet metal, metal siding, metal roofing, lockers, toilet partitions, office furniture for filing and storage);
7. Paint (allowed only in exterior installations).
8. Compost

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Deliver materials in recyclable or in reusable packaging such as cardboard, wood, paper, or reusable blankets, which will be reclaimed by supplier or manufacturer for recycling.

B. General: Minimize packaging materials to maximum extent possible while still ensuring protection of materials during delivery, storage, and handling.
   1. Unacceptable Packaging Materials: Polyurethane, polyisocyanate, polystyrene, polyethylene, and similar plastic materials such as "foam" plastics and "shrink-fit" plastics.

C. Reusable Blankets: Deliver and store materials in reusable blankets and mats reclaimed by manufacturers or suppliers for reuse where program exists or where program can be developed for such reuse.

D. Pallets: Where pallets are used, suppliers shall be responsible to ensure pallets are removed from site for reuse or for recycling.

E. Corrugated Cardboard and Paper: Where paper products are used, recycle as part of construction waste management recycling program, or return to material's manufacturer for use by manufacturer or supplier.

F. Sealants, Paint, Primers, Adhesives, and Coating Containers: Return to supplier or manufacturer for reuse where such program is available.

1.6 PROJECT CONDITIONS

A. No smoking will be permitted in indoor Project site locations, as per California Labor Code (Section 400-6413.5).

B. Certifications:
   1. Environmental Product Certification:
      a. Include manufacturer certification indicating product contains maximum recycled content possible without being detrimental to product performance
      b. Include certification indicating cleaning materials comply with requirements of these Specifications.

C. Construction Ventilation and Preconditioning:
   1. Temporary Construction Ventilation: Maintain sufficient temporary ventilation of areas where materials are being used that emit VOCs. Maintain ventilation continuously during installation, and until emissions dissipate after installation. If continuous ventilation is not possible via building's HVAC system(s) then ventilation shall be supplied via open windows and temporary fans, sufficient to provide no less than three air changes per hour.
      a. Period after installation shall be sufficient to dissipate odors and elevated concentrations of VOCs. Where no specific period is stated in these

Specifications, a time period of 72 hours shall be used.

b. Ventilate areas directly to outside; ventilation to other enclosed areas is not acceptable.

2. During dust producing activities (e.g. drywall installation and finishing) turn ventilation system off, and openings in supply and return HVAC system shall be protected from dust infiltration. Provide temporary ventilation as required.
3. Preconditioning: Prior to installation, allow products which have odors and significant VOC emissions to off-gas in dry, well-ventilated space for 14 calendar days to allow for reasonable dissipation of odors and emissions prior to delivery to Project site.
   a. Condition products without containers and packaging to maximize off-gassing of VOCs
   b. Condition products in ventilated warehouse or other building. Comply with substitution requirements for consideration of other locations.

D. Protection:

1. Moisture Stains: Materials with evidence of moisture damage, including stains, are not acceptable, including both stored and installed materials; immediately remove from site and properly dispose. Take special care to prevent accumulation of moisture on installed materials and within packaging during delivery, storage, and handling to prevent development of molds and mildew on packaging and on products.
   a. Immediately remove from site and properly dispose of materials showing signs of mold and signs of mildew, including materials with moisture stains.
   b. Replace moldy materials with new, undamaged materials.
2. Ducts: Seal ducts during transportation, delivery, and construction to prevent accumulation of construction dust and construction debris inside ducts.

1.7 SEQUENCING

A. Environmental Issues:

1. On-Site Application: Where odorous and/or high VOC emitting products are applied on-site, apply prior to installation of porous and fibrous materials. Where this is not possible, protect porous materials with polyethylene vapor retarders.
2. Complete interior finish material installation no less than fourteen (14) days prior to Substantial Completion to allow for building flush out

PART 2 - PRODUCTS

2.1 CHEMICALS OF CONCERN

A. Chemicals of Concern are those chemicals listed below as toxic air contaminants, carcinogens, teratogens, reproductive toxins, and chemicals with established Chronic Reference Exposure Levels (REL):

B. Carcinogens: Chemicals listed as probable or known human carcinogens in the latest published edition of the following two lists:

1. California Environmental Protection Agency, Air Resources Board (ARB), list of Toxic Air Contaminants (California Air Toxics).http://www.arb.ca.gov/toxics/summary/summary.htm

2. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA), Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). http://www.oehha.ca.gov/prop65/prop65_list/Newlist.html.

C. Reproductive Toxicants: Chemicals known to cause reproductive toxicity including birth defects or other reproductive harm in the latest published edition of the following list: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA), Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). http://www.oehha.ca.gov/prop65/prop65_list/Newlist.htm.

D. Chemicals with established Chronic Reference Exposure Levels (REL): Chronic RELs have been developed for 65 hazardous airborne substances as of January 2001. A chronic REL is an airborne concentration level that would pose no significant health risk to individuals indefinitely exposed to that level. RELs are based solely on health considerations, and are developed from the best available data in the scientific literature. The California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA) establishes and publishes RELs. *(Note 16)*

Table 1. Chronic Reference Exposure Levels for organic chemicals with possible indoor sources, based on the California OEHHA list as of September 2002. (The most recent list shall be used for this specification as published at http://www.oehha.org/air/chronic_rels/allChrels.html) :

	Substance (CAS #)	*Listed in CAPCOA (1993)*	*Chronic Inhalation REL (µg/m^3)*	*Hazard Index Target(s)*	*Human Data*
1	Acetaldehyde* (75-07-0)	☑	9	Respiratory system	
2	Acrolein (107-02-8)	☑	0.06	Respiratory system; eyes	
3	Acrylonitrile (107-13-1)	☑	5	Respiratory system	
4	Ammonia (7664-41-7)	☑	200	Respiratory system	☑
5	Arsenic (7440-38-2) & arsenic compounds	☑	0.03	Development; Cardiovascular system; Nervous system	
6	Benzene (71-43-2)	☑	60	Hematopoietic system; development; nervous system	☑
7	Beryllium (7440-41-7) and beryllium compounds	☑	0.007	Respiratory system; immune system	☑
8	Butadiene (106-99-0)		20	Reproductive system	
9	Cadmium (7440-43-9) & cadmium compounds	☑	0.02	Kidney; respiratory system	☑
10	Carbon tetrachloride (56-23-5)	☑	40	Alimentary system; development; nervous system	
11	Carbon disulfide (75-15-0)		800	Nervous system; reproductive system	☑
12	Chlorinated dioxins (1746-01-6) & dibenzofurans (5120-73-19)	☑	0.00004	Alimentary system (liver); reproductive system; development; endocrine system; respiratory system; hematopoietic system	
13	Chlorine (7782-50-5)	☑	0.2	Respiratory system	
14	Chlorine dioxide (10049-04-4)		0.6	Respiratory system	

15	Chlorobenzene (108-90-7)	☑	1000	Alimentary system; kidney; reproductive system	
16	Chloroform (67-66-3)	☑	300	Alimentary system; kidney; development	
17	Chloropicrin (76-06-2)	☑	0.4	Respiratory system	
18	Chromium hexavalent: soluble except chromic trioxide	☑	0.2	Respiratory system	
19	Chromic trioxide (as chromic acid mist)	☑	0.002	Respiratory system	☑
20	Cresol mixtures (1319-77-3)	☑	600	Nervous system	
21	Dichlorobenzene (1,4-) (106-46-7)	☑	800	Nervous system; respiratory system; alimentary system; kidney	
22	Dichloroethylene (1,1) (75-35-4)	☑	70	Alimentary system	
23	Diesel Exhaust*		5	Respiratory system	
24	Diethanolamine (111-42-2)		3	Cardiovascular system; nervous system	
25	Dimethylformamide (N,N-) (68-12-2)		80	Alimentary system ; respiratory system	☑
26	Dioxane (1,4-) (123-91-1)	☑	3,000	Alimentary system; kidney; cardiovascular system	
27	Epichlorohydrin (106-89-8)	☑	3	Respiratory system; eyes	
28	Epoxybutane (1,2-) (106-88-7)		20	Respiratory system; cardiovascular system	
29	Ethylbenzene (100-41-4)		2,000	Development; alimentary system (liver); kidney; endocrine system	
30	Ethyl chloride (75-00-3)	☑	30,000	Development; alimentary system	
31	Ethylene dibromide (106-93-4)	☑	0.8	Reproductive system	☑
32	Ethylene dichloride (107-06-2)	☑	400	Alimentary system (liver)	
33	Ethylene glycol (107-21-1)		400	Respiratory system; kidney; development	☑
34	Ethylene glycol monoethyl ether (110-80-5)	☑	70	Reproductive system; hematopoietic system	
35	Ethylene glycol monoethyl ether acetate (111-15-9)	☑	300	Development	
36	Ethylene glycol monomethyl ether (109-86-4)	☑	60	Reproductive system	
37	Ethylene glycol monomethyl ether acetate (110-49-6)	☑	90	Reproductive system	
38	Ethylene oxide (75-21-8)	☑	30	Nervous system	
39	Formaldehyde (50-00-0)	☑	3	Respiratory system; eyes	☑
40	Glutaraldehyde (111-30-8)	☑	0.08	Respiratory system	
41	Hexane (n-) (110-54-3)		7000	Nervous system	
42	Hydrazine (302-01-2)	☑	0.2	Alimentary system; endocrine system	
43	Hydrogen chloride (7647-01-0)	☑	9	Respiratory system	
44	Hydrogen cyanide (74-90-8)	☑	9	Nervous system; endocrine system; cardiovascular system	☑

45	Hydrogen sulfide (7783-06-4)	☑	10	Respiratory system	
46	Isophorone (78-59-1)		2000	Development; liver	
47	Isopropanol (67-63-0)		7,000	Kidney; development	
48	Maleic anhydride (108-31-6)	☑	0.7	Respiratory system	
49	Manganese & manganese compounds	☑	0.2	Nervous system	☑
50	Mercury & mercury compounds (inorganic)	☑	0.09	Nervous system	☑
51	Methanol (67-56-1)	☑	4,000	Development	
52	Methyl bromide (74-83-9)	☑	5	Respiratory system; nervous system; development	
53	Methyl chloroform (71-55-6)	☑	1,000	Nervous system	
54	Methyl isocyanate (624-83-9)		1	Respiratory system; reproductive system	
55	Methyl t-butyl ether (1634-04-4)		8,000	Kidney; eyes; alimentary system (liver)	
56	Methylene chloride (75-09-2)	☑	400	Cardiovascular system; nervous system	☑
57	Methylene dianiline (4,4'-) (101-77-9)	☑	20	Eyes; alimentary system (hepatotoxicity)	
58	Methylene Diphenyl Isocyanate (101-68-8)		0.7	Respiratory system	
59	Naphthalene (91-20-3)	☑	9	Respiratory system	
60	Nickel & compounds (except nickel oxide)	☑	0.05	Respiratory system; hematopoietic system	
61	Nickel oxide (1313-99-1)		0.1	Respiratory system; hematopoietic system	
62	Phenol (108-95-2)	☑	200	Alimentary system; cardiovascular system; kidney; nervous system	
63	Phosphine (7803-51-2)	☑	0.8	Respiratory system; alimentary system; nervous system; kidney; hematopoietic system	
64	Phosphoric acid (7664-38-2)		7	Respiratory system	
65	Phthalic anhydride (85-44-9)	☑	20	Respiratory system	☑
66	Propylene (115-07-1)		3,000	Respiratory system	
67	Propylene glycol monomethyl ether (107-98-2)		7,000	Alimentary system (liver)	
68	Propylene oxide (75-56-9)	☑	30	Respiratory system	
69	Selenium and selenium compounds (other than hydrogen selenide)	☑	20	Alimentary system; cardiovascular system; nervous system	☑
70	Styrene (100-42-5)	☑	900	Nervous system	☑
71	Sulfuric acid (7664-93-9)		1	Respiratory system	
72	Tetrachloroethylene* (perchloroethylene) (127-18-4)	☑	35	Kidney; alimentary system (liver)	
73	Toluene (108-88-3)	☑	300	Nervous system; respiratory system; development	
74	Toluene diisocyanates (2,4- &2,6-)	☑	0.07	Respiratory system	☑

75	Trichloroethylene (79-01-6)	☑	600	Nervous system; eyes	☑
76	Triethylamine (121-44-8)		200	Eyes	
77	Vinyl acetate (108-05-4)		200	Respiratory system	
78	Xylenes (m-, o-, p-)	☑	700	Nervous system; respiratory system	☑

2.2 SUBSTITUTIONS

A. Substitutions Environmental Issues: Requests for substitutions shall comply with requirements specified in Section 01630 – Product Substitution Procedures, with following additional information required where environmental issues are specified.

1. Indicate each proposed substitution complies with requirements for VOCs.
2. Owner, in consultation with Architect reserve right to reject proposed substitutions where data for VOCs is not provided or where emissions of individual VOCs are higher than for specified materials.
3. Comply with specified recycled content and other environmental requirements.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Building Flush Out: Just prior to Substantial Completion, flush out building continuously (i.e. 24 hours per day, seven (7) days a week) using maximum tempered outside air (or maximum amount of outside air while achieving reasonable indoor temperature) for at least fourteen (14) calendar days. If interruptions of more than a few hours are required for testing and balancing purposes, extend flush out period accordingly.

1. When Contractor is required to perform touch-up work, provide temporary construction ventilation during installation and extend building flush-out by a minimum of four (4) days after touch-up installation with maximum tempered outside air for 24 hr per day.
2. If construction schedule permits, extend flush-out period beyond 15 days.
3. Return ventilation system to normal operation following flush-out period to minimize energy consumption.

3.2 CLEANING

A. Final Cleaning Environmental Issues:

1. Clean interior and exterior surfaces exposed to view; remove temporary labels, stains, and foreign substances; polish transparent and glossy surfaces using cleaning and maintenance products as described in Part 1 of this Section.
2. Clean equipment and fixtures to sanitary condition using cleaning and maintenance products as described in Part 1 of this Section.
3. Vacuum carpeted and soft surfaces with high efficiency particulate arrestor (HEPA) vacuum.
4. If ducts were not sealed during construction, and contain dust or dirt, clean ducts using HEPA vacuum immediately prior to Substantial Completion and prior to using ducts to circulate air. Oil film on sheet metal shall be removed before shipment to site. However, ducts shall be inspected to confirm that no oil film is

present. Remove oil.

5. Replace all air filters (i.e., pre and final filters) just prior to Substantial Completion.
6. Remove and properly dispose of recyclable materials using construction waste management program described in Section 01565 – Site Waste Management Program.

3.3 PROTECTION

A. Environmental Issues:

1. Protect interior materials from water intrusion or penetration; where interior products not intended for wet applications are exposed to moisture, immediately remove from site and dispose of properly.
2. Protect installed products using methods that do not support growth of molds and mildews.
   a. Immediately remove from site materials with mold and materials with mildew.

END OF SECTION

Project Name: ___________________________

RECYCLED CONTENT CERTIFICATION FORM

This form is to be completed by a Corporate Officer of the Product Manufacturer for the General Contractor. The General Contractor must return the certification, completed for each product with recycled content as required by specific Specification Sections. Attach additional sheets if necessary.

GENERAL CONTRACTOR	SUBCONTRACTOR/INSTALLER	PRODUCT MANUFACTURER
Name:	Name:	Name:
Address:	Address:	Address:
Telephone, fax, e-mail:	Telephone, fax, e-mail:	Telephone, fax, e-mail:

Item #	Product Category[1&2] (Include if applicable)	Product Description CSI section number[3] (Needed for all products)	Quantity Bid	Unit of measure	Cost of material, (Excluding installation labor)	Weight in pounds	% Virgin Content[5]	% Post-consumer[6]	% Post-industrial[7]	Total %[8]
							As a percent of total weight			
		CSI section:								100
		CSI section:								100
		CSI section:								100
		CSI section:								100
		CSI section:								100
		CSI section:								100

Printed Name: (a corporate officer) *Title* *Date* *Signature*

GENERAL NOTES:

A. The Public Contract Code Sections, listed below, apply to California public (DGS) projects only. The required document has been adapted for use on other types of projects.

B. Public Contract Code Sections 10233, 10308.5, and 10354 require all vendors and contractors to certify in writing, under penalty of perjury, to the state agency awarding a contract, the minimum, if not the exact percentage, of post-consumer and post-industrial material in the materials, goods, or supplies offered or used.

C. Public Contract Code Section 12205(a) requires all state agencies to require all contractors to certify in writing, under penalty of perjury, the minimum, if not the exact percentage, of post-consumer and post-industrial material in the materials, goods, or services provided or used.

NOTES:

(1) Product Category: (Fill in above, if applicable. This information is used to determine compliance with the State Agency Buy Recycled Campaign.)

1. Compost/Co-compost
2. Glass Products
3. Lubricating Oils
4. Paint
5. Plastic Products
6. Paper Products
7. Printing and Writing Papers
8. Solvents
9. Steel Products
10. Tires
11. Tire-derived Products

(2) Product category is used for State agency reporting for State projects, excluding public schools. Products that are made from multiple material types should be reported in the product category of the material type representing most of the product. The amount of material used in the product can be measured by weight or volume. If, for instance, a chair is made from steel, aluminum, and plastic and most of the material, either by weight or volume, is plastic, report it as a plastic product. If, however, most of the product, either by weight or volume, is steel, report the purchase as a steel product.

(3) Identify the Construction Specifications Institute (CSI) Specification Section number for the product, as indicated in the Project Specifications.

(4) Below are products preliminarily identified in the Project Specifications as having minimum recycled content requirements. Refer to the Project Specifications for individual sections in the specifications for recycled content level that must be achieved. Recycled content guidelines shall include, but not be limited to, the products below (to be revised for each project):

1. Parking Bumpers (Section 2760)
2. Fluid-Applied Waterproofing (Section 07140)
3. Concrete reinforcement (Section 03200)
4. Bentonite Waterproofing (Section 07170)
5. Structural steel (Section 05120)
6. Metal Decking (Section 05300)
7. Building Insulation (Section 07210)
8. Steel doors and frames (Section 08110)
9. Glazing (Section 08800)
10. Paints and Coatings (Section 09900)
11. Cold-Formed Metal Framing (Section 05400)
12. Gypsum board (Sections 09255, 09260, 09265)
13. Ceramic tile (Section 09300)
14. Acoustical ceilings (Section 09510)
15. Resilient flooring (Section 09650)
16. Carpeting (Sections 09682, 09686)
17. Metal Toilet Compartments (Section 10160)
18. Identifying Devices (Section 10400)
19. Architectural Woodwork (Section 06400)

(5) Virgin material content is that portion of the product made from non-recycled material, that is, the material is neither post-industrial nor post-consumer material.

(6) Post-consumer material is defined as "a finished material which would have been disposed of as a solid waste, having completed its life cycle as a consumer item, and does not include manufacturing wastes." This is material such as a newspaper that is read, recycled and then made into recycled content newsprint or some other recycled product. Post-consumer material is generally any product that is bought by the consumer, used, and then recycled into another product.

(7) Post-industrial (also referred to as pre-consumer or secondary material) is defined as "fragments of finished products or finished products of a manufacturing process, which has converted a resource into a commodity of real economic value, but does not include excess virgin resources of the manufacturing process." This is material such as newsprint that is trimmed from a roll in the paper plant that is returned to the beginning of the process to make recycled content newsprint. The material (product) did not get to the consumer before being recycled. Post-industrial material DOES NOT include post-consumer material. FOR EXAMPLE: If a Printing and Writing Paper contained 20% post-consumer material, you would indicate 20 in the post-consumer column and 80 in the virgin column. If the product had 40% secondary material and 20% post-consumer material, you would indicate 40 in the post-industrial column, 20 in the post-consumer column, and 40 in the virgin column.

(8) The sum of the percentages for virgin, post-consumer, and post-industrial content must equal 100 percent.

N O T E S

SECTION 01350 - SPECIAL ENVIRONMENTAL REQUIREMENTS NOTES

NOTE 1:

1.1 Section 01350 is one of the most important specification sections in terms of guiding and controlling the environmental impact of a project. It is this general requirements section that sets the tone for the project and informs the environmental requirements of individual specification sections. While an attempt has been made to simplify this specification, it is understood that the issues raised may be new to the Architect, and may appear complex. For this reason, it is recommended that the section be carefully reviewed prior to use, and that it be integrated carefully into the Project Manual Specification. If uncertainty exists, it may be advisable to utilize the services of a Specifications consultant, and an Indoor Air Quality consultant.

1.2 The requirements of section 01350 apply to almost all the specification sections, and these other sections should be coordinated with section 01350.

1.3 The Special Environmental Requirements incorporate three major issues:

A. Energy conservation and efficiency: Specification Section 01350 references energy conservation and efficiency, and deals specifically with the other two issues.

B. Indoor environmental and air quality: Specification section 01350 references the environmental issues, and deals specifically with indoor air quality. Reducing pollutant sources in buildings is probably the most effective method for improving the indoor air quality. This specification section provides a requirement for major materials used inside a building to be submitted for an emissions chamber test prior to installation. Various Chemicals of Concern are listed and the results of the chamber test should be reviewed for conformance with the limits established here. The laboratory write up of the test results will indicate whether the test results meet the specification requirements or not.

C. Resource efficient materials and systems: This specification section provides a method for documenting products recycled content and is based on the California State Agency Buy Recycled Campaign (SABRC). The SABRC must be used for California Department of General Services (DGS) projects (excluding public schools), and the documentation requirements have been adapted to conform to specification requirements and for use on other projects as a reporting tool to the Architect and to the project Owner.

1.4 Life Cycle Assessment: Life Cycle Assessment (LCA) is needed to assist the Architect in making judgments about the appropriate use of specific materials and systems. Since LCA is not yet sufficiently developed, it is not presented in this specification, but much of the information requested by this section will be helpful in the future when LCA becomes available.

NOTE 2:

2.1 Specification section 01350 article 1.2, Design Requirements is included in this specification specifically to advise the contractor about the design requirements used by the design team in the design of the project and the preparation of the

Contract Documents. The Contractor needs access to this information if they decide to propose sustainable building enhancements, or if they decide to propose material and system substitution requests. For substitution requests, the contractor will need to compare the proposed substitution to the specified product and will need to highlight the sustainable building design requirements in their proposals.

2.2 Some of the goals noted below may appear to be contradictory, and the project team may need to evaluate and make a selection based on project-specific goals. The design team for each project should evaluate project priorities and goals with the school district as part of the design process prior to preparation of Construction Documents.

NOTE 3:

3.1 For school projects, special care should be taken with lighting design for the sports fields, and to achieve a safe site environment at night.

NOTE 4:

4.1 Specification Section 01350 Article 1.2, I: When using composite wood products that contain post-consumer recycled content, there is a possibility that the final product may contain lead, arsenic, and semi-volatile organic compounds including Pentachlorophenol, Chlordane, and Chlorpyrifos. While there are currently no established safe air concentration limits for these compounds, it is important to recognize that they may present a significant health hazard. Therefore, bulk testing of the product is recommended to show that they are free of contamination. The Project client should be notified of the compound content as they may be required under CA Proposition 65 to notify building users of the presence of these compounds if such compounds are installed into a building. The architect and the Project client should make a determination whether such products should be installed.

NOTE 5:

5.1 For State funded projects, State agencies are required to comply with the State of California Public Contract Code Sections 10233, 10308.5 and 10354. School projects are not required to comply with these codes; however, the certification form has been adapted for use on school projects.

NOTE 6:

6.1 For FSC accredited certifiers visit http://fsuc.org/html/index.html

6.2 *"Well-managed" shall mean forests that are being managed through professionally-administered forestry management and logging plans that ensure regeneration of desired species so that timber growth equals or exceeds harvesting rates in both quantity and quality over the long term. Other considerations include protecting rivers and streams from degradation, minimizing damage of the forest when harvesting, promoting biodiversity, operating in concert with the lawful interests of local populations, and maximizing both the yield and value of the forest products.

NOTE 7:

7.1 It is not practical to request the submission of MSDS's for review by the Architect in design-bid-build construction procurement projects. This information should be requested and reviewed by the Architect in the design phases. Specification Section 01350 Article 1.3, B should contain the following text when using non design-build construction procurement methods. However, the Architect should in all circumstances obtain this information prior to specifying a product:

A. "Environmental Issues Data: Furnish material safety data sheets (MSDS) for materials where as required in each specific Specification sections. All :

B. MSDSs submitted must contain specific chemical content data identifying the percent of the total product mass represented by each listed chemical in the MSDS.

C. Chemicals listed as proprietary or not listed on MSDS shall be separately listed and submitted to Architect for review under a non-disclosure agreement.

D. Requirements for identified chemicals are not limited to those listed by OSHA as hazardous nor to those present at greater than 1% by weight.".

7.2 Specification Section 01350 Article 1.3 B and D require the contractor to provide Emission Test Data for materials and products. The information requested by this requirement, is usually obtained by the General Contractor, through the subcontractor and from the product manufacturer. The manufacturer obtains this information from the test laboratory, and both of the testing laboratories listed in this section are experienced at preparing the data in a form usable by the architect Much of the test description provided in this specification section is given for the benefit of the laboratory.

NOTE 8:

8.1 The Architect should review the pattern of the decay curve for TVOC and formaldehyde for the duration of the test. The decay curve should be dropping over time. If TVOC and formaldehyde emissions are high and/or if the decay curve is not dropping, temporary ventilation may be needed in the installation area.

NOTE 9:

9.1 The Architect should compare emissions from maintenance products to those from maintenance products for other materials being considered for the same use for Project, and evaluate. Exclude materials whose maintenance products VOC emissions are in upper half of those compared for same applications.

9.2 There is now in draft form a State of California, Department of General Services, Technical Specification For the Evaluation of Environmentally Preferable Janitorial Chemicals. For State funded Projects, excluding public schools, it is necessary to refer to these guidelines. Both are available on the internet at: http://www.ciwmb.ca.gov/greenbuilding/Specs/Janitorial.doc and http://www.resd.dgs.ca.gov/BPM/lists.htm

NOTES

NOTE 10:

10.1 Indoor air emissions testing laboratories are currently not widely available. The following laboratories are listed for the convenience of the specification user. However, this listing does not imply an endorsement of the laboratories by the authors or by the State of California nor does the absence of a laboratory from the list imply that it would not be acceptable.

10.2 The State of California does not currently have a certification process for labs analyzing air samples.

10.3 In the future, California's Department of Health Services (DHS) is planning to certify, accredit, or otherwise approve of those laboratories performing air monitoring analyses as mandated by Senate Bill 2203 (Sher et al., Statutes of 2000). This became effective on January 2, 2001 (California Health and Safety Code Section 100825-100920). The DHS does maintain a list of commercial laboratories without any endorsement or evaluation of the quality of services (Refer to http://www.cal-iaq.org/FIRMS/).

NOTE 11:

11.1 Emissions testing provides emission factors for the test specimen under the loading and ventilation used in the test. The emission factor must be used with project-specific product loading and ventilation data to determine whether a material complies with the requirements of this specification. Re-testing is not necessary for different material applications, but new calculations are required.

NOTE 12:

12.1 The OEHHA Chronic REL for Formaldehyde is the goal, but in most cases it cannot be met. Due to its status as an identified carcinogen, a preferred approach to control of formaldehyde concentrations is based on the principle of ALARA, As Low As Reasonably Achievable.

12.2 Note that the OEHHA Chronic REL for formaldehyde is approximately the same as the typical concentration in outdoor air. Products containing wood even without formaldehyde-based resins and many common fibrous glass insulation products are made with formaldehyde-based resins as are many composite wood products. In order to not eliminate many common building products that will inevitably emit some formaldehyde, we have used an alternative concentration limit of 28 $\mu g/m^3$ (23 ppb) based on OEHHA's recommended maximum concentration in office environments. Nevertheless, due to formaldehyde's status as a listed carcinogen, it is strongly recommended that the ALARA (As Low As Reasonably Achievable) approach be applied and that 3 $\mu g/m^3$ be the goal.

NOTE 13:

13.1 These specifications require that the Contractor provide calculations obtained from the product manufacturer and prepared by the testing laboratory. The Contractor will need to provide to the laboratory the required dimensional information needed for the calculations. Should the architect elect to perform these calculations, he/she may do so using information, design assumptions, and materials quantities for the Project.

N O T E S

NOTE 14:

14.1 Specification Section 01350, 1.4, D 10, Reporting Requirements: The items required by the reporting requirements should be included in a submittal and used by the Architect as follows:

A. Compounds listed on OEHHA list – Reported calculated concentration should be equal to or less than ½ the OEHHA regulations.

B. Compounds on Proposition 65 list – Report these to the project owner (school district). The Owner is required by law to identify these compounds with a warning sign in the building.

C. California Toxic Air Contaminants list – available at http://www.arb.ca.gov/toxics/taclist.htm Report the calculated concentrations of any compounds on this list to the Owner for their information. The Architect should attempt to obtain this information in the design phases if possible so that timely decisions can be made.

NOTE 15:

15.1 The SABRC is mandatory for State projects, excluding public schools, but can be used for all projects as adapted in these specifications as a way to report to the Architect, and a school district, the recycled content of a product.

15.2 For updated information on SABRC recycled-content goals, recycled-content categories and reporting procedures, contact Jerry Hart: 1001 I Street, P.O. Box 4025, Sacramento, California 95812-4025 91, telephone 916.341.6000 or 1501 E. Orangethorpe Ave., Suite 150, Fullerton, California 92831, telephone 714.449.7072, fax 714.449.4780, *www.ciwmb.ca.gov* and *www.ciwmb.ca.gov/BuyRecyled/StateAgency*.

NOTE 16:

16.1 The list of Chronic Inhalation RELs is included in this draft specification for illustrative purposes only. The Architect should use the latest version of the list, copied from the website, when preparing the specifications.

16.2 Note that not all Chemicals of Concern are included on the lists at this time and that revisions to the lists will occur from time-to-time. These revisions may require re-testing of some products, and/or re-evaluating of some products using available test data.

REFERENCES

1. California State Agency Buy Recycled Campaign, The Department of General Services and the Californian Integrated Waste Management Board. http://www.ciwmb.ca.gov/buyrecycled/stateagency

2. Sustainable Building Technical Manual, Green Building Design, Construction and Operations, Chapters 13 and 15 for Indoor Air Quality and Building Commissioning produced by Public Technology Inc. and co-sponsored by the U.S. Green Building Council, Department of Energy, and the U.S. Environmental Protection Agency, 1996.

3. Leon Alevantis, M.S., P.E., Indoor Air Quality Section, Environmental Health Laboratory Branch, Division of Environmental and Occupational Disease Control,

California Department of Health Services, Reducing Occupant Exposure to Volatile Organic Compounds (VOCs) from Office Building Construction Materials: Non-Binding Guidelines, July 1996. Available on the web at http://www.cal-iaq.org/VOC/

4. LEED™ Reference Guide, Leadership in Energy and Environmental Design, Green Building Rating System, version 2.0, May 2000, U.S. Green Building Council. http://www.usgbc.org.

5. California Proposition 65. *The Safe Drinking Water and Toxic Enforcement Act of 1986*. Available on the internet at http://www.oehha.ca.gov/prop65.html

6. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. 2002. *Air Toxics Hot Spots Program Risk Assessment Guidelines, Part III, Technical Support Document for the Determination of Noncancer Chronic Reference Exposure Levels*, California Environmental Protection Agency, Office of Environmental Health Hazards Assessment, Air Toxicology and Epidemiology Section, September 2002 (or most recent edition). Available on the internet at: http://www.oehha.org/air/chronic_rels/allChrels.html

7. State of California, 2001b. *Technical Specification for Environmentally Preferable Janitorial Chemicals – Golden Seal Program*. Available on the internet at: http://www.ciwmb.ca.gov/greenbuilding/Specs/Janitorial.doc

8. State of California, 2002b. List of Environmentally Preferable Janitorial Chemicals for the Department of General Services. Available on the internet at: http://www.resd.dgs.ca.gov/BPM/lists.htm

SECTION 01565 - SITE WASTE MANAGEMENT PROGRAM

PART 1 - GENERAL

1.1 SUMMARY

A. Environmental Issues: Project requires special Site Waste Management Program.
   1. Waste Management Goals: A minimum 75% of total Project waste shall be diverted from landfill.
   2. Provide documentation to show evidence that waste management, recycling, and reuse of recyclable and reusable materials have been maximized.
   3. Effect optimum control of solid wastes.
   4. Prevent environmental pollution and damage.

B. Related Work:
   1. Section 01350: Special environmental requirements.

1.2 DEFINITIONS

A. Inert Fill: A permitted facility that accepts inert waste such as asphalt and concrete exclusively.

B. Class III Landfill: A landfill that accepts non-hazardous waste such as household, commercial, and industrial waste, including construction, remodeling, repair, and demolition operations.

C. Construction and Demolition Waste: Includes solid wastes, such as building materials, packaging, rubbish, debris, and rubble resulting from construction, remodeling, repair, and demolition operations.
   1. Rubbish: Includes both combustible and noncombustible wastes, such as paper, boxes, glass, crockery, metal and lumber scrap, tin cans, and bones.
   2. Debris: Includes both combustible and noncombustible wastes, such as leaves and tree trimmings that result from construction or maintenance and repair work.

D. Chemical Waste: Includes petroleum products, bituminous materials, salts, acids, alkalis, herbicides, pesticides, organic chemicals and inorganic wastes.

E. Sanitary Wastes:
   1. Garbage: Refuse and scraps resulting from preparation, cooking, distribution, or consumption of food.
   2. Sewage: Domestic sanitary sewage.

1.3 SUBMITTALS

A. Site Waste Management Program: Prior to commencement of Work, schedule and conduct meeting with Owner and Architect to discuss proposed Site Waste Management Program.
   1. Develop mutual understanding relative to details of recycling, and rebate programs.
   2. Prepare and submit a written and graphic Site Waste Management Program including, but not limited to, the following:
      a. Indicate procedures to be implemented.

b. Estimate total Project waste to be generated, and estimated cost of disposing of Project waste in landfills.

c. Estimate total cubic yards of following waste categories to be diverted from landfill.

   i. Clean dimensional wood, palette wood.

   ii. Plywood, oriented strand board, and medium density fiberboard.

   iii. Cardboard, paper, packaging.

   iv. Other items as directed by Owner and Architect.

d. Estimate amounts of following waste categories in appropriate units (weight, feet, square yards, gallons).

   i. Metals.

   ii. Gypsum board.

   iii. Carpet.

   iv. Paint.

   v. Other items as directed by Owner and Architect.

e. Submit permit or license and location of waste disposal areas.

f. Submit procedures for recycling/re-use program.

g. Submit procedures for rebate programs.

h. Revise and resubmit Site Waste Management Program as required by Owner and Architect.

   i. Review of Contractor's Site Waste Management Program will not relieve Contractor of responsibility for control of pollutants and other environmental protection measures.

B. Submit summary of solid waste generated by Project with each application for progress payment, on form acceptable to Owner and Architect. Include the following information:

1. Name of firm accepting the recovered materials or waste materials.
2. Specify type of facility (e.g. recycler, processor, Class III landfill, MRF).
3. Location of the facility.
4. Type of materials.
5. Net weights of each type of recovered material.
6. Date of delivery.
7. Value of the materials or tipping fee paid.

C. Prepare 3-ring binder with rebate information and product documentation as required for Owner to qualify for rebate programs; submit binder with final closeout submittals.

1.4 RECYCLING PROGRAM

A. Recycling: Implement recycling program that includes separate collection of waste materials of following types as applicable to Project:

1. Asphalt.
2. Land clearing debris.

3. Soil.
4. Trees and shrubs.
5. Concrete and concrete blocks.
6. Brick and masonry materials.
7. Untreated lumber.
8. Clean dimensional wood and palette wood.
9. Plywood, oriented strand board, and medium density fiberboard.
10. Paper – bond.
11. Paper (e.g. newsprint).
12. Cardboard and paper packaging materials.
13. Plastics.
14. Rigid foam.
15. Insulation.
16. Ferrous metal.
17. Non-ferrous metals (e.g. copper, aluminum, etc.).
18. Glass.
19. Gypsum board (unpainted).
20. Carpet and pad.
21. Paint.
22. Beverage containers.
23. Plumbing fixtures.
24. Electrical fixtures and wires.
25. Others as appropriate.

B. Separation of Waste: Contractor and subcontractors are both required to separate recyclable materials into bins and to arrange for delivery of recyclable materials to recycling depot. Clearly label all recycling containers and list acceptable and unacceptable materials.

C. Handling: Keep materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to recycling process.
   1. Clean materials that are contaminated prior to placing in collection containers.
   2. Arrange for collection by or delivery to appropriate recycling center or transfer station that accepts construction and demolition waste for purpose of recycling.

D. Participate in Re-Use Programs: Rebates, tax credits, and other savings obtained for recycled or re-used materials shall accrue to Contractor.

END OF SECTION

N O T E S

SECTION 01565 - SITE WASTE MANAGEMENT PROGRAM NOTES

JUSTIFICATION

1.1. The site waste management program documents the amount of construction debris generated on a construction site and tracks its ultimate dispersal to recycling facilities and other disposal sites.

APPLICATION

2.1 The requirements of section 01350 apply to section 01565.

2.2 Section 01565 will also inform the "final cleaning" article of each specification section.

REFERENCES FOR MORE INFORMATION:

3.1 California State Agency Buy Recycled Campaign, The Department of General Services and the Californian Integrated Waste Management Board. www.ciwmb.ca.gov/BuyRecycled/StateAgency

3.2 LEED™ Reference Guide, *Leadership in Energy and Environmental Design, Green Building Rating System*, version 2.0, May 2000, U.S. Green Building Council. http://www.usgbc.org

SECTION 01810 - COMMISSIONING

PART 1 - GENERAL *(NOTE 1.1)*

1.1 WORK INCLUDED

A. Work included in this section: Oversight, coordination, and documentation of the following:
   1. Commissioning of selected systems and equipment specified under Division 13 Special Construction.
   2. Commissioning of selected systems and equipment specified under Division 15 Mechanical.
   3. Commissioning of selected systems and equipment specified under Division 16 Electrical.
   4. Commissioning of systems and equipment specified under Division 17 Energy Management and Control Systems.

1.2 RELATED SECTIONS AND REQUIREMENTS

A. Requirements of Division 1 General Requirements apply to all work in this section.

B. Related Sections:
   1. Section 15970 Mechanical Commissioning.
   2. Section 16080 Electrical Commissioning.
   3. Section 17959 EMCS Commissioning.

1.3 GENERAL

A. Building Commissioning is a quality assurance process that has as its goal that all systems perform interactively and according to design intent under the full range of expected operating conditions. The Contractor shall ensure that all systems are fully commissioned and that commissioning is fully documented as specified in this Section.

B. Commissioning Team. The Commissioning Team for the construction and post-construction period shall include:
   1. Contractor Members:
      a. Commissioning Coordinator (see paragraph 1.3C).
      b. Division 13, 15, 16, and 17 project managers plus key subcontractors where appropriate, including the Test & Balance contractor.
   2. Owner Members:
      a. Owner’s Representative.
      b. Owner plant operator/engineer (during the functional testing and training phases only).
      c. Architectural/Engineering (A/E) Design team members.

C. Commissioning Coordinator:
   1. The Contractor shall procure and provide the services of the Commissioning Coordinator.
   2. Qualifications:
      a. Cumulative of eight or more years experience in one or more of the following

for projects of similar size and complexity:

i. Building mechanical or electrical system commissioning.

ii. Building mechanical or electrical system construction project management.

iii. Building mechanical or electrical system coordination services for a general contractor.

iv. Building mechanical system test & balance project management.

b. University graduate with BS in mechanical engineering, electrical engineering, or building science.

c. Five or more years of experience with project management software such as MS Project or equal.

d. Either an employee of or direct subcontractor to the Contractor.

3. Services to be provided: See paragraph 3.1.

1.4 SUBMITTALS

A. See Division 1.

B. Commissioning Coordinator Qualifications. Prior to any commissioning work taking place, submit Commissioning Coordinator's resume listing applicable experience for review and approval by the Owner’s Representative.

C. Equipment submittals and shop drawings: See Divisions 13, 15, 16, and 17.

D. Commissioning Reports:

1. Start-up and Factory Tests.

a. See Divisions 13, 15, 16, and 17 for requirements.

b. Compile after all equipment has been started and submit five copies to Owner’s Representative for review and approval.

2. Pre-functional Tests:

a. See Divisions 13, 15, 16, and 17 for checklists.

b. Compile after all equipment pre-functional forms have been completed and submit five copies to Owner’s Representative for review and approval.

3. Test and Balance Reports.

a. See Section 15950 Testing, Adjusting and Balancing for content and quantity of reports.

b. Include only those reports developed after spot checks and associated rebalancing have been completed.

4. Functional Tests:

a. See Division 16 and 17 for forms.

b. Compile after all tests have been completed and submit five copies to Owner’s Representative for review and approval.

5. Demonstration Tests:

a. Tests will be a subset of Functional Tests and will be identified one day prior to the Tests by the Owner’s Representative. See Divisions 16 and 17 for expected time required.

b. Compile after all tests have been completed and submit five copies to Owner’s Representative for review and approval.

6. Trend Reviews:
   a. Data to be provided to Owner's Representative in electronic format specified in Division 17.
7. Final Report:
   a. Include the following completed documentation:
      i. System/Equipment Matrix (see Paragraph 3.1A.2).
      ii. Start-up and Factory Tests.
      iii. Test and Balance Reports.
      iv. Pre-functional test documentation.
      v. Functional test documentation.
   b. Format and Procedure:
      i. Submit two draft copies for review and comment by Owner's Representative, who will return one copy.
      ii. Make changes noted on returned copy and compile final draft.
      iii. Submit Final Report in the following format:
         a) Five bound copies.
         b) One electronic copy on CD in format readable by software on Operator's Workstation, as specified in Division 17. Reports may be scanned from paper copies but word-searchable electronic versions preferred.
         c) One electronic copy as above copied onto the Operator's Workstation server.
8. Operations and Maintenance Manuals: See Divisions 13, 15, 16, and 17.
9. Training manuals: See Divisions 13, 15, 16, and 17.
10. Recommissioning Management Manual
    a. Prepare and submit 1 copy of a Recommissioning Management Manual containing the following information organized into a 3-ring binder with tabbed sections as listed.
       i. Design Intent. (Material provided by the Owner's Representative)
          a) Final version of the owner's requirements and design basis narratives, including brief descriptions of each system.
       ii. Controls. (Material provided by Division 17 Contractor.)
          a) As-built sequences of operation for all equipment.
          b) Controls drawings
          c) A list of time of day schedules and a schedule to review them for relevance and efficiency.
          d) A list of all user adjustable setpoints and reset schedules with rationale for their selection and range.
       iii. Energy and Water Efficiency Measures. (Material provided by Owner Representative.)
          a) A description and rationale for all energy and water saving features and strategies with operating and instructions.
          b) Guidelines for establishing and tracking benchmarks for whole

building energy use and equipment efficiencies of cooling, heating, and service hot water equipment.

iv. Seasonal Issues.

v. Calibration. (Material provided by Division 17 Contractor.)

a) Recommendations for recalibration frequency of sensors and devices by type and use.

vi. Continuing Commissioning Plan (Material provided by Owner Representative.)

a) Recommended frequency for recommissioning by equipment type or system, with reference to tests conducted during initial commissioning.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 COMMISIONING COORDINATION

A. Commissioning Coordinator shall:

1. Prepare schedule of commissioning activities specified in Divisions 13, 15, 16, and 17 including:
   a. Submission of equipment submittals and shop drawings
   b. Equipment start-up and pre-functional tests
   c. Factory start-up and inspection of equipment
   d. Test and balance
   e. EMCS calibration and start-up
   f. Electrical system functional testing
   g. EMCS system functional testing
   h. EMCS demonstration tests (to Owner's Representative)
   i. EMCS trending initiation
   j. EMCS trend review data distribution (to Owner's Representative)
   k. Submission of operations and maintenance manuals
   l. Development and submission of record drawings
   m. Training of Owner personnel
   n. Preparation of Final Commissioning Report
2. Prepare a system and equipment commissioning matrix with a line item for each piece of equipment and each subsystem specified to be commissioned under Division 13, 15, 16, and 17. The System/Equipment matrix shall include for each line item:
   a. Equipment tag or name.
   b. Service.
   c. Location.
   d. Responsible subcontractor.
   e. The due date and actual completion date for the following (where applicable):
      i. Submittals.

ii. Shop drawings.

iii. Factory test.

iv. Equipment set.

v. Preliminary operations and maintenance manuals indicating start-up procedures.

vi. Pre-start verification.

vii. Equipment start-up.

viii. Pre-functional test.

ix. Test and balance.

x. Functional performance test.

xi. Operations and maintenance manuals.

xii. Record drawings.

xiii. Training.

3. Complete the commissioning matrix as activities are completed, and distribute to Commissioning Team at least one day prior to each Team meeting or when requested by Owner's Representative.
4. Schedule and chair meetings of Commissioning Team:
   a. Commissioning Team shall be notified of all meeting times and locations at least two weeks prior to the meeting.
   b. Contractor Members of Commissioning Team shall attend all scheduled meetings; Owner Members of Commissioning Team shall be invited to all meetings and attend where they feel their attendance is beneficial or where required to witness demonstration tests and training.
   c. Prior to start of construction until 30 days prior to start-up of any equipment:

      i. One scoping meeting shall occur prior to any Division 13, 15, 16, and 17 submissions of equipment submittals or shop drawings. Meeting shall include a discussion of preliminary commissioning schedule and roles of each Team member.

      ii. Bi-monthly progress meetings (more frequent if required in the judgment of the Commissioning Coordinator; less frequent if requested by the Commissioning Coordinator and approved by the Owner's Representative).
   d. 30 days prior to start-up of any equipment through start of functional testing: Bi-weekly progress meetings (more frequent if required in the judgment of the Commissioning Coordinator; less frequent if requested by the Commissioning Coordinator and approved by the Owner's Representative).
   e. During functional testing until their completion: Weekly progress meetings (more frequent if required in the judgment of the Commissioning Coordinator; less frequent if requested by the Commissioning Coordinator and approved by the Owner's Representative).
   f. After functional testing until all commissioning documentation is complete: Meetings as required in the judgment of the Commissioning Coordinator.
5. Supervise pre-functional and functional testing performed by Contractor's Members of Commissioning Team:

a. Coordinate tests among Team Members and schedule tests so that required work for each trade is complete prior to tests being performed.
b. Ensure that tests are successfully completed by reviewing test forms for completeness and positive response, and ensuring forms have been signed by the Team Member who performed the work. (The Commissioning Coordinator is not required to perform or witness any pre-functional or functional tests.)
c. Compile test documentation and submit to the Owner's Representative for review and approval.
d. Coordinate and ensure resolution of punchlists from Owner's Representative.

6. Supervise and witness demonstration tests performed by Contractor's Members of Commissioning Team, also witnessed by the Owner's Members of the Commissioning Team:
   a. Compile test documentation and submit to the Owner's Representative for review and approval.
   b. Coordinate and ensure resolution of punchlists from the Owner's Representative.
   c. Coordinate retesting where required until tests are successfully completed.
7. Coordinate EMCS post-construction and post-occupancy trend reviews with Division 17 Contractor:
   a. Ensure trends are initiated as specified in Division 17. The post-construction review will occur directly after functional testing is complete (see Division 17 for exact time period). Two post-occupancy reviews will occur, one after approximately 6 months of operation, and one approximately two months prior to the end of the warranty period.
   b. Ensure data is transmitted in required format to Owner's Representative.
   c. Coordinate and ensure resolution of trend review punchlists from the Owner's Representative.
   d. Coordinate retesting where required until tests are successfully completed.
8. Maintain a master deficiency and resolution log developed from punchlists, including status and date of resolution of each deficiency. Provide the Owner's Representative with regular progress reports.
9. Coordinate and confirm completion of training of Owner personnel as specified under Divisions 13, 15, 16, and 17.
10. Compile and submit Final Commissioning Report.
11. Compile and submit the Recommissioning Management Manual.

3.2 REMEDIAL WORK

A. Remedial work shall be performed at no additional cost to the Owner.

B. Remedial work shall include re-performing any commissioning or other tests related to remedial work once remediation is complete at no additional cost to the Owner.

C. Contractor shall compensate Owner's Representative on a time and material basis at standard billing rates for any additional time required to witness additional demonstration tests or to review additional EMCS trends beyond the initial tests (see paragraphs 3.1A.6.c and 3.1A.7.d), at no additional cost to the Owner.

3.3 SYSTEM ACCEPTANCE

A. Specified Division 13, 15, 16, and 17 systems shall be considered commissioned and substantially complete when the following have been submitted and approved by Owner Representative:
   1. Final Commissioning Report.
   2. Post-construction trend review.
   3. Other completion documentation as defined in Divisions 13, 15, 16, and 17, including Owner sign-off that training has been completed.
   4. All remedial action associated with punchlists developed by the Owner's Representative.

B. Remedial action required to address deficiencies identified by post-occupancy trend reviews shall be covered by the system warranty at no additional cost to the Owner.

END OF SECTION

SECTION 01810 - COMMISSIONING - NOTES

NOTE 1:

1.1 This document describes "Two Party" commissioning, i.e. the A/E design team and the construction team. This is one particular paradigm for commissioning. Another popular paradigm is "3rd Party" commissioning, where an outside Commissioning Agent is brought in to commission the building. 3rd Party commissioning is not described in this document.

REFERENCES

Portland Energy Conservation Inc., www.peci.org.

California Commissioning Collaborative, www.cacx.org.

SECTION 02848- PARKING BUMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Work included: Furnish and install all recycled composite parking bumpers (wheel stops) and speed bumps.

B. Related work:

1. Special environmental requirements are specified in Section 01350.

C. Related documents.

D. Definitions.

1.2 SUBMITTALS

A. Submittals procedures: Refer to Section 01350.

B. Special environmental requirements: Submit the following in accordance with the requirements of Section 01350:

1. Resource Efficient Product Data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental Issues Certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (Specifications, submittals, and/or test data) in terms of recycled content and recyclability.

C. Product data: Submit manufacturer's published descriptive literature and complete specifications for products specified herein.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Packaging and shipping: Refer to Section 01350 for use of recycled or recyclable packing materials.

B. Acceptance at site.

1.4 WARRANTY

A. Manufacturer's warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURED PRODUCTS

A. Parking bumpers: "Power-Stop", by Collins & Aikman (510-536-2600 or 800-444-0254), or approved equal meeting the following requirements:

1. Material: 100% recycled composite parking stops manufactured from fibrous reinforcement and a blend of vinyl, nylon fibers, post consumer plastics, and post industrial plastics. Wheel stops shall contain 30-35% post consumer recycled content, 65-70% post industrial recycled content, and shall contain no wood products. In addition, parking bumpers shall be 100% recyclable.
2. Physical Properties:

a. Density (ASTM D79): 60 lbs/cf.
b. Leaching (EPA 1311): Pass.
c. Water Absorption (ASTM D1027): 0.2%
d. Nail Pull-Out (ASTM 1761): 170 lbs.
e. Compressive Stress (ASTM D198): 3104 psi.
f. Modulus of Rupture (ASTM D198): 2307 psi.
g. Modulus of Elasticity (ASTM D198): 120731.

3. Size: 5-3/4” x 3-1/2” x length indicated.
4. Provision for Installation: Pre-drill parking stops for two 5/8” diameter rebar anchors.

B. Speed bumps: 96-100% post-consumer recycled plastic with countersunk holes for bolts. Provide lag bolts and required hardware. Exposed surfaces shall be dense and smooth, free of pits, honeycombs or other defects.

C. Installation adhesives: As recommended by parking stop and speed bump manufacturer for surface to which installed. Adhesives must comply with the requirements of Section 01350 if used in an indoor environment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of conditions.

3.2 PREPARATION

A. Substrate preparation.

3.3 INSTALLATION

A. General:

1. Low-VOC emission type, heavy duty adhesives as recommended by the manufacturer (for indoor application) or expansion-type steel bolts set in holes drilled into concrete paving.

3.4 CLEANING AND PROTECTION

A. Construction cleaning

B. Protection of work: Protect completed or in-place wheel stops and speed bumps from damage due to subsequent construction or finishing activities.

C. Damaged or defective work.

END OF SECTION

SECTION 02848 - PARKING BUMPERS NOTES

JUSTIFICATION

1.1 Use of recycled product reduces impact on landfill and lessens depletion of natural resources.

EXAMPLE PRODUCTS/MANUFACTURERS

2.1 “Power-Stop”, by Collins & Aikman (510-536-2600 or 800-444-0254), http://www.ciwmb.ca.gov/BuyRecycled/StateAgency

SECTION 02870 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special environmental requirements (submit the following in accordance with the requirements of Section 01350):

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.2 QUALITY ASSURANCE

A. Certification.

1.3 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Seating, tables, trash/recycling receptacles, playfield equipment and structures.

B. Recycled content: 90- 99% Post Consumer Recycled Content

C. Recyclablity: Product shall be recyclable.

END OF SECTION

SECTION 02870 - SITE FURNISHINGS NOTES

JUSTIFICATION

1.1 Use of recycled product reduces impact on landfill and lessens depletion of natural resources.

1.2 Alternative is to use FSC-certified sustainably harvested woods.

APPLICATION

2.1 Plastic Lumber can be used to fabricate benches and other site furnishings. Recycled shredded rubber is used for playground surfacing.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 Playfield Equipment (Turf)

3.2 Seating:

A. Landscape Forms
431 Lawndale Avenue
Kalamazoo, MI 49001-9828

B. Recycle Design
U.S. Plastic Lumber, LTD
2600 W. Roosevelt Road
Chicago, IL 60608
312-491-2500
www.recycledesign.com

3.3 Tables:

A. Landscape Forms
431 Lawndale Avenue
Kalamazoo, MI 49001-9828
800-521-2546

3.4 Trash/Recycling Receptacles:

A. Landscape Forms
431 Lawndale Avenue
Kalamazoo, MI 49001-9828
800-521-2546

B. CIWMB Recycled Contents Products Database
www.ciwmb.ca.gov/BuyRecycled/StateAgency

SECTION 03050 - BASIC CONCRETE MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFERENCES

A. Appropriate references for fly ash and its chemical composition (either Class C or Class F).

1.2 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.3 QUALITY ASSURANCE

A. Certification.

1.4 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content:
   1. Concrete shall have a fly ash content of 25% maximum replacing Portland cement.
   2. Reinforcing steel with a minimum of 90% post consumer recycled content.
   3. Use recycled aggregate (type, quality and quantity to be reviewed by structural engineer).

2.2 MIXES

A. Fly ash content shall be added in the ranges listed in article 2.1.A.1.a, above, depending on application (consult with Structural Engineer).

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 03050 - BASIC CONCRETE MATERIALS AND METHODS NOTES

JUSTIFICATION

1.1 In concrete, replacement of Portland cement with fly ash utilizes a combustion by-product of the coal industry that would otherwise be stockpiled or landfilled. Landfilling or stockpiling of fly ash can cause leaching of trace heavy metals into the soil and from there, potentially into ground water. Therefore use fly ash only when it is available. Do not specify it if there is no supply. Since it is a by-product of coal burning, stimulating this polluting process to obtain fly ash should not be considered sustainable.

1.2 Concrete with fly ash conserves natural resources by utilizing less Portland cement and thus conserves energy that would have been expended in its production. The energy used to transport fly ash from another state to California is considered less than the energy used to produce Portland cement within State. Reducing the production of Portland cement reduces CO_2 emissions into the air.

1.3 The range of acceptable fly ash content should be carefully studied. Typically, 25% replacement by weight of Portland cement with fly ash is the maximum currently accepted by the concrete industry. Higher fly ash content in the range of up to 60% should be considered, but a structural engineer needs to be contacted. High fly ash content may cause aldehyde-containing superplasticizers (these chemicals may impact the indoor air quality) to be used to speed up drying/curing. Fly ash causes an increase in drying/curing time and strength is gained at a slower rate.

1.4 Class C and F fly ash have different performance characteristics in terms of strength and air-entrainment (freeze-thaw protection).

APPLICATION

2.1 Mat slabs, foundations and other structural applications (with chemical additives to speed drying).

2.2 Caltrans uses fly ash content in concrete for road beds.

OTHER ISSUES

3.1 The use of recycled aggregate should be regarded with care since reused aggregate may affect the strength and hardness properties of concrete.

REFERENCES FOR MORE INFORMATION

4.1 ISG Resources
950 Andover Park East, Suite 24
Tukwila, WA 98188
206-394-1364
800-426-5171
www.flyash.com

SECTION 03300- CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 REFERENCES

A. Appropriate references for fly ash and its chemical composition (either Class C or Class F).

1.2 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.3 QUALITY ASSURANCE

A. Certification

1.4 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content:
   1. Concrete shall have a fly ash content of 25% maximum replacing Portland cement.
   2. Reinforcing steel with a minimum of 90% post consumer recycled content.
   3. Use recycled aggregate (type, quality and quantity to be reviewed by structural engineer).

2.2 MIXES

A. Fly ash content shall be added in the ranges listed in article 2.1.A.1, above, depending on application (consult with Structural Engineer).

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

N O T E S

SECTION 03300 - CAST-IN-PLACE CONCRETE NOTES

JUSTIFICATION

1.1 In concrete, replacement of Portland cement with fly ash utilizes a combustion by-product of the coal industry that would otherwise be stockpiled or landfilled. Landfilling or stockpiling of fly ash can cause leaching of trace heavy metals into the soil and from there, potentially into ground water. Therefore use fly ash only when it is available. Do not specify it if there is no supply. Since it is a by-product of coal burning, stimulating this polluting process to obtain fly ash should not be considered sustainable.

1.2 Concrete with fly ash conserves natural resources by utilizing less Portland cement and thus conserves energy that would have been expended in its production. The energy used to transport fly ash from another state to California is considered to be less than the energy used to produce Portland cement within State [attribution]. Reducing the production of Portland cement reduces CO_2 emissions into the air.

1.3 The range of acceptable fly ash content should be carefully studied. Typically, 25% replacement by weight of Portland cement with fly ash is the maximum currently accepted by the concrete industry. Higher fly ash content in the range of up to 60% should be considered, but a structural engineer needs to be contacted. High fly ash content may cause aldehyde-containing superplasticizers (these chemicals may impact the indoor air quality) to be used to speed up drying/curing. Fly ash causes an increase in drying/curing time and strength is gained at a slower rate.

1.4 Class C and F fly ash have different performance characteristics in terms of strength and air-entrainment (freeze-thaw protection).

APPLICATION

2.1 Mat slabs, foundations and other structural applications (with chemical additives to speed drying).

2.2 Caltrans uses fly ash content in concrete for road beds.

OTHER ISSUES

3.1 The use of recycled aggregate should be regarded with care since reused aggregate may affect the strength and hardness properties of concrete.

REFERENCES

4.1 ISG Resources
950 Andover Park East, Suite 24
Tukwila, WA 98188
206-394-1364
800-426-5171
www.flyash.com

SECTION 03400 - PRECAST PANELS WITH STONE VENEER OR TILE

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.2 QUALITY ASSURANCE

A. Certification.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide stone from source located in California, preferably within a 500-mile radius of the project site.

B. Recycled Content:
   1. For tile: 77% Post consumer recycled content.

C. Recyclability:
   1. Tile products shall be 100% recyclable.

PART 3 - EXECUTION

3.1 CLEANING:

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program Section 01565.

END OF SECTION

N O T E S

SECTION 03400 - PRECAST PANELS WITH STONE VENEER OR TILE NOTES

JUSTIFICATION

1.1 If stone originates from a quarry close to the precaster and/or is close to the site, transportation energy and costs may be reduced.

1.2 Energy consumption is reduced if local quarries and recycled content are included.

1.3 Recycled content tiles reduce use of raw materials (natural resources) and have less impact on landfill.

1.4 Local fabrication of stone panels is preferred.

1.5 Fly ash in concrete.

APPLICATION

2.1 Exterior skin/cladding

COST IMPACT

3.1 No premium

SECTION 04050 - BASIC MASONRY MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.2 QUALITY ASSURANCE

A. Certification.

1.3 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content:
   1. Replace Portland Cement with 30% fly ash content by weight
   2. Aggregates: Use recycled aggregate where possible.

B. Recyclability.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program Section 01565.

END OF SECTION

SECTION 04050 - BASIC MASONRY MATERIALS AND METHODS NOTES

JUSTIFICATION:

1.1 In concrete, replacement of Portland cement with fly ash utilizes a combustion by-product of the coal industry that would otherwise be stockpiled or landfilled. Landfilling or stockpiling of fly ash can cause leaching of trace heavy metals into the soil and from there, potentially into ground water. Therefore use fly ash only when it is available. Do not specify it if there is no supply. Since it is a by-product of coal burning, stimulating this polluting process to obtain fly ash should not be considered sustainable.

1.2 Concrete with fly ash conserves natural resources by utilizing less Portland cement and thus conserves energy that would have been expended in its production. The energy used to transport fly ash from another state to California is considered to be less than the energy used to produce Portland cement within State [attribution]. Reducing the production of Portland cement reduces CO_2 emissions into the air.

1.3 The range of acceptable fly ash content should be carefully studied. Typically, 25% replacement by weight of Portland cement with fly ash is the maximum currently accepted by the concrete industry. Any higher fly ash content may cause aldehyde-containing superplasticizers (these chemicals may impact the indoor air quality) to be used to speed up drying/curing. Fly ash causes an increase in drying/curing time and strength is gained at a slower rate.

1.4 Class C and F fly ash have different performance characteristics in terms of strength and air-entrainment (freeze-thaw protection).

APPLICATION

2.1 Concrete masonry units and other molded building shapes from stone, ceramic brick or tile, concrete, glass, adobe or other material.
- *The Art & Architecture Thesaurus Browser*

COST IMPACT

3.1 Fly ash in CMU is not currently being produced.

SECTION 04400 - STONE

PART 1 - GENERAL

1.1 SUMMARY

A. Countertops.

1.2 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.
3. Salvaged Stone Certification: Origin of salvaged stone shall be _______ _______. Provide certification stating stone originates from_________________________.

1.3 QUALITY ASSURANCE

A. Certification.

1.4 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide stone quarried and fabricated within a 500 mile radius of the project site.

B. Where possible, use salvaged stone. Recommended minimum for project shall total 30%.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 04400 - STONE NOTES

JUSTIFICATION

1.1 The use of locally quarried stone reduces transportation energy use and costs.

1.2 The local fabrication of stone reduces transportation energy use and costs.

APPLICATION

2.1 Exterior cladding, paving, flooring, surfacing material countertops, site furnishings.

COST IMPACT

3.1 No premium for locally quarried/fabricated stone.

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Cold Spring Granite
www.coldspringgranite.com

SECTION 05050 - BASIC METAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.2 QUALITY ASSURANCE

A. Certification.

PART 2 - PRODUCTS

2.1 MATERIALS

A. SABRC (State Agency Buy Recycled Campaign) Standards: Provide recycled content minimums for all steel derived products as described by CIWMB. (Refer to the following website for updated recycled content percentages: http://www.ciwmb.ca.gov/BuyRecycled/StateAgency)

PART 3 - PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565. .

END OF SECTION

N
O
T
E
S

SECTION 05050 - BASIC METAL MATERIALS AND METHODS NOTES

JUSTIFICATION

1.1 Recycled content in metal studs may contain up to 60% post consumer recycled content. This conserves natural resources and saves energy in the production of new steel.

1.2 An analysis of the energy expended in steel recycling balanced with the energy used to produce steel should be studied.

APPLICATION

2.1 Metal Framing

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 Angles Metal: Metal Studs

SECTION 05100 - STRUCTURAL STEEL

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.2 QUALITY ASSURANCE

A. Certification.

1.3 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content:

1. Provide Structural Steel with a minimum of 90% post consumer recycled content.
2. SABRC (State Agency Buy Recycled Campaign) Standards: provide recycled content minimums as described by the California Integrated Waste Management Board (CIWMB). Refer to: http://www.ciwmb.ca.gov/BuyRecycled/StateAgency.

B. Recyclability

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

N O T E S

SECTION 05100 - STRUCTURAL STEEL NOTES

JUSTIFICATION

1.1 The use of up to 90% post consumer recycled content conserves natural resources and contributes to energy savings in the form of energy saved in the production of new steel.

1.2 An analysis of the energy expended in steel recycling balanced with the energy used to produce steel should be studied.

APPLICATION

2.1 Structural load-bearing components and shapes.

COST IMPACT

3.1 None. Most steel produced in the U.S. has recycled content. The amount varies.

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 U.S. Steel
www.usx.com/ussteel

4.2 NuCor
www.nucor.com

SECTION 05300 - METAL DECK

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.2 QUALITY ASSURANCE

A. Certification.

1.3 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide steel deck with minimum post consumer recycled content.

B. Recyclability.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 05300 - METAL DECK NOTES

JUSTIFICATION

1.1 Use of recycled steel reduces use of raw materials (Iron as a natural resource) in the production of new steel.

1.2 An analysis of the energy required (expended) to recycle steel balanced with the energy used to produce steel should be studied.

APPLICATION

2.1 Structural flooring or roofing components.

COST IMPACT

3.1 None. Most steel produced in the U.S. has recycled content. The amount varies.

SECTION 06060 - WOOD MATERIALS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content; Forest-Stewardship Council-certified sustainable harvested wood products, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.

1.2 QUALITY ASSURANCE

A. Certification.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide Forest-Stewardship Council - certified sustainable harvested wood products in accordance with Specification Section 01350.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the Site Waste Management Program, section 01565.

END OF SECTION

NOTES

SECTION 06060 - WOOD MATERIALS NOTES

JUSTIFICATION

1.1 The use of FSC (Forest Stewardship Council) – certified sustainably harvested woods promote socially responsible and economically viable farming practices which ensure the continuing availability of wood and protect old-growth forests.

1.2 The use of Low VOC emitting backer boards (MDF) improve indoor air quality.

APPLICATION

2.1 Solid wood and veneers for cabinetry, interior architectural woodwork, surfacing material, paneling, molding, and trim.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 EcoTimber
www.ecotimber.com

3.2 Plywood and Lumber Sales
www.pals4wood.com

3.3 Hayward Lumber
(831) 646-8184

3.4 Eudura
www.eudurawood.com

3.5 VIDA, a Division of
Architectural Forest Enterprises
(800) 483-6337
http://www.4vida.com

REFERENCES FOR MORE INFORMATION

4.1 Refer to Specification Section 01350, Article 1.3 and
http://tsuc.org/html/index.html

SECTION 06065 - PLASTIC MATERIALS

PART 1 - GENERAL

1.1 SUMMARY

A. Plastic lumber to be used for fabrication of custom building elements such as decks, etc.

1.2 SUBMITTALS

A. Special environmental requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability,
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of recycled content, recyclability, and indoor air quality.

1.3 QUALITY ASSURANCE

A. Certification.

1.4 DELIVERY STORAGE AND HANDLING

A. Packaging.
   1. Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content.
   1. Provide plastic lumber with 98% post consumer recycled purified high-density polyethylene (HDPE).

B. Recyclabilty.
   1. 100% by manufacturer.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 06065 - PLASTIC MATERIALS NOTES

JUSTIFICATION

1.1 The use of recycled content plastic (HDPE or PET) materials reduces impact on landfill, reduces natural resource depletion and conserves natural resources.

APPLICATION

2.1 Surfacing, laminating, countertops. Avoid PVCproducts where possible.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 RecycleDesign, Durawood

3.2 U.S. Plastic Lumber, Ltd
2600 W. Roosevelt Road
Chicago, IL 60608
312-491-2500
www.recycledesign.com

3.3 Yemm & Hart
www.yemmhart.com

SECTION 06070 - WOOD TREATMENT

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special environmental requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability,
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of recycled content, recyclability, and indoor air quality.
   3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data for treated wood used at indoor locations. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.2 QUALITY ASSURANCE

A. Certification.

1.3 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

1.4 SITE CONDITIONS

A. Temporary Ventilation: Provide Temporary Ventilation during on-site application of wood treatment as described in Section 01350.

B. Precondition off-site as described in Section 01350.

1.5 SEQUENCING

A. Install high–VOC emitting products before porous materials as required by Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Indoor Air Quality Criteria:
   1. Product shall be low/no odor.

2. Product shall meet emissions test criteria.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 06070 - WOOD TREATMENT NOTES

JUSTIFICATION

1.1 Emissions testing is an emulation of how a product will perform when installed. Testing is recommended where treated wood products are used indoors.

1.2 Worker safety is enhanced through the use of arsenic-free preservative.

APPLICATION

2.1 Above-ground and ground-contact applications, in contact with fresh water and in marine splash zone exposures: Decking, outdoor furniture, piles, fences, outdoor structures, piers and docks.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 CSI (Chemical Specialties, Inc.)
Preserve and Preserve Plus
Arsenic-free, Chromium-Free
www.treatedwood.com

SECTION 06080 - FACTORY-APPLIED WOOD COATINGS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special environmental requirements (submit the following in accordance with the requirements of Section 01350):

1. Resource efficient product data: Submit required information concerning project recyclability (packaging).
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.2 QUALITY ASSURANCE

A. Certification.

1.3 DELIVERY STORAGE AND HANDLING

A. Precondition materials in a ventilated warehouse prior to delivery to site as required by Section 01350.

1.4 SITE CONDITIONS

A. Install high-VOC emitting materials prior to porous materials.

1.5 SEQUENCING

A. Install high-VOC emitting products before porous materials as required by Section 01350.

PART 2 - EXECUTION

2.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

SECTION 06100 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUBMITTALS

A. Special environmental requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, FSC-certified sustainably harvested wood products, and product recyclability,
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of recycled content, recyclability, and indoor air quality.
   3. Indoor Air Quality: For MDF; Submit Material Safety Data Sheets (MSDS) and emission test data. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.2 QUALITY ASSURANCE

A. Certification.

1.3 DELIVERY STORAGE AND HANDLING

A. Certified wood shall be kept separate from non-certified wood. Auditing process as mandated by certifiers shall be complied with.

1.4 SITE CONDITIONS

A. Protect from moisture.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Used reclaimed or salvaged lumber.

B. Use FSC-certified sustainably harvested wood products.

C. Use composite wood products with low VOC emissions as described in Section 01350.

D. Recycled Content:
   1. For MDF: 94% recycled content, at least 10% of which shall be post-consumer

recycled content.

E. Recyclability:

1. MDF shall be recyclable.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 06100 - ROUGH CARPENTRY NOTES

JUSTIFICATION

1.1 Use of reclaimed or salvaged wood protects old-growth forests and endangered species' environments, conserves natural resources and energy that would have been expended to mill and shape lumber.

1.2 Use of sustainably harvested woods promotes responsible wood farming production techniques, protects old growth forest.

1.3 MDF with recycled content of 94% post-industrial recycled wood residuals conserves natural resources and reduces impact on landfill.

1.4 Energy is saved in terms of cutting trees, transportation costs to/from mills, to site, etc.

APPLICATION

2.1 Plywood, planks, framing lumber, studs, structural panels and boards.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 EcoTimber
www.ecotimber.com

3.2 MDF – Sierra Pine
www.sierrapine.com

3.3 MDF – All Green CanFibre
(888) 355-4733

SECTION 06200 - FINISH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

A. Woods, veneers, backer boards (core board, composite wood products, or MDF with recycled content).

1.2 SUBMITTALS

A. Special environmental requirements (submit the following in accordance with the requirements of Section 01350):

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, FSC-certified sustainably harvested wood products, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of recycled content, recyclability, and indoor air quality.
3. Indoor Air Quality: For core boards, composite wood products, and MDF; submit Material Safety Data Sheets (MSDS) and emission test data. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.3 QUALITY ASSURANCE

A. Certification.

1.4 DELIVERY STORAGE AND HANDLING

A. Keep certified products separate from non-certified products, for auditing proposes (as mandated by the certifier).

B. Keep wood products dry.

C. Packaging: Refer to Division 1.

1.5 SITE CONDITIONS

A. Keep wood products dry.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use FSC-certified sustainably harvested wood from well-managed forests. Provide FSC-certified MDF where possible.

B. Indoor Air Quality Criteria:

  1. Only low odor/low-VOC-emitting core boards, composite wood products, and MDF shall be used on the project. No exposed particleboard will be allowed.

C. Recyclability:

  1. MDF shall be recyclable.

D. Recycled Content For MDF:

  1. 94% recycled content, at least 10% of which shall be post-consumer recycled content.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as per Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01350.

END OF SECTION

SECTION 06200 - FINISH CARPENTRY NOTES

JUSTIFICATION

1.1 The use of certified sustainably harvested woods from well-managed forests conserves natural resources and old growth forests, and promotes the use of environmentally responsible renewable resources.

1.2 In addition, the use of reclaimed/salvaged casework should be considered.

1.3 Use of low VOC-emitting core boards (Medium Density Fiberboard - MDF) reduces emissions of chemicals into indoor air. MDF uses recycled content of 94% post-industrial recycled wood residuals. Some MDF is manufactured from certified wood.

APPLICATION

2.1 All interior applications including: paneling, trim, millwork, cabinetry, molding and veneers.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 MDF – Sierra Pine
www.sierrapine.com

3.2 MDF – All Green can Fibre
(888) 355 – 4733

3.3 Reclaimed Wood: EcoTimber
www.ecotimber.com

SECTION 06400 - INTERIOR ARCHITECTURAL WOODWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Cabinets, countertops

1.2 SUBMITTALS

A. Special Environmental Requirements (submit the following in accordance with the requirements of Section 01350):
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.
   3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data from MDF and formaldehyde-containing materials. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.3 QUALITY ASSURANCE

A. Certification.

1.4 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

B. Storage:
   1. For soybean resin and newsprint product, pallets and flat packs to be stored on a flat, dry, hard, level surface.

C. Mold and mildew prevention.
   1. Refer to Specification Section 01350, 1.7.C.1

1.5 SITE CONDITIONS

A. Mold and mildew prevention.
   1. Refer to Specification Section 01350, 1.7.C.1

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide composite surfacing materials with recycled content and containing no formaldehyde.

B. Generic Name:
   1. 100% Agricultural straw waste panels finished with dyes and an ultra violet cured coating.
   2. Soybean protein resin and fiber with cellulose from waste newsprint. Unsealed. 30% - 40% soybean flour with 100% recycled content.
   3. Renewable agricultural fiber by-product panels with 94% recycled content.

C. Recycled content for MDF:
   1. 94% recycled content, at least 10% of which shall be post-consumer recycled content.

D. Composite surfacing materials and MDF shall be recyclable.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 06400 - INTERIOR ARCHITECTURAL WOODWORK NOTES

JUSTIFICATION

1.1 The use of alternative composite surfacing materials reduces natural resources depletion and reduces impact on landfill, because they are manufactured from renewable agricultural resources.

1.2 Alternative composite surfacing materials with no solvents are low-or-no VOC-emitting products and contribute to good indoor air quality.

APPLICATION

2.1 Surfacing, paneling, furniture and doors.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 Soybean/Recycled Newsprint Composite Surfacing Material:

3.2 Phenix Biocomposites,
Environ Biocomposite
P.O. Box 609
Mankato, MN 56002-0609
800-324-8181

3.3 Renewable Agricultural By-Product Composite Surfacing Material:

3.4 Phenix Biocomposites,
Biofiber
P.O. Box 609
Mankato, MN 56002-0609
800-324-81

CONTENTS

CONTENTS 1
DISCLAIMER 2
SECTION 07211 - GLASS FIBER BATT BUILDING INSULATION 3
SECTION 07211 - GLASS FIBER BATT BUILDING INSULATION – NOTES 8
SECTION 07212 – MINERAL WOOL BATT BUILDING INSULATION 13
SECTION 07212 – MINERAL WOOL BATT BUILDING INSULATION – NOTES 15
SECTION 07213 – CELLULOSE SPRAY (LOOSE) BUILDING INSULATION 17
SECTION 07213 – CELLULOSE SPRAY (LOOSE) BUILDING INSULATION – NOTES 20
SECTION 07214 – GLASS FIBER (BLOWN-IN) BUILDING INSULATION 24
SECTION 07214 – GLASS FIBER (BLOWN-IN) BUILDING INSULATION – NOTES 26
SECTION 07215 – MINERAL WOOL (BLOWN-IN) BUILDING INSULATION 28
SECTION 07215 – MINERAL WOOL (BLOWN-IN) BUILDING INSULATION – NOTES 30
SECTION 07216 – CELLULOSE SPRAY (WALL CAVITY) BUILDING INSULATION 32
SECTION 07216 – CELLULOSE SPRAY (WALL CAVITY) BUILDING INSULATION – NOTES 34
SECTION 07217 – FOAM BOARD BUILDING INSULATION 38
SECTION 07217 – FOAM BOARD BUILDING INSULATION – NOTES 43
SECTION 07218 – RADIANT BARRIER BUILDING INSULATION 46
SECTION 07218 – RADIANT BARRIER BUILDING INSULATION – NOTES 49
SECTION 07240 – EXTERIOR INSULATING FINISH SYSTEM (EIFS) 52
SECTION 07240 – EXTERIOR INSULATING FINISH SYSTEM (EIFS) – NOTES 54
SECTION 07300 – SHINGLES, ROOF TILES, AND ROOF COVERINGS 56
SECTION 07300 – SHINGLES, ROOF TILES, AND ROOF COVERINGS – NOTES 58
SECTION 07500 – MEMBRANE ROOFING 61
SECTION 07500 – MEMBRANE ROOFING – NOTES 64
SECTION 07610 – SHEET METAL ROOFING 67
SECTION 07610 – SHEET METAL ROOFING – NOTES 69
SECTION 07814 – CEMENTITIOUS FIREPROOFING 71

DISCLAIMER

The authors have tried to make the information in this document as accurate and useful as possible. However, they make no warranty, express or implied, and assume no legal liability for the information in this report. References to specific manufacturers or products are provided for the convenience of the reader and shall not be considered endorsements.

These specifications were prepared as a 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 warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

SECTION 07211 - GLASS FIBER BATT BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. Rated R-value of insulation: The thermal resistance of insulation as specified by the manufacturer in units of hr. sq. ft. °F/Btu at a mean temperature of 75 °F. The R-value refers to the thermal resistance of the insulation alone and does not include the thermal resistance of other building materials or air films.

1.2 SYSTEM DESCRIPTION

A. [Standard] [Bi-component] glass fiber batt insulation installed in [wall cavity] [ceiling cavity] [roof] to meet the required thermal performance. (*Note 1.4).*

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS: Submit the following in accordance with the requirements of Section 01350:
1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data.

1.4 QUALITY ASSURANCE

A. Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

1.6 WARRANTY

A. Insulation manufacturer shall warrant that the actual thermal performance of the specified product when properly installed at specified thickness and sealed against air and water vapor infiltration for ____ years.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: [Standard glass fiber] [Bi-component glass fiber] batt insulation. *(Note 1.3).*

B. Performance Requirements:
1. Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.4).*

2. Roof: Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.4).*

C. Recycled content: Minimum 30% post consumer, 20% post-industrial (50% total) for glass fiber core. *(Note 1.5).*

D. Product shall emit no formaldehyde when tested per § 01350. *(Note 1.6).*

E. Provide encapsulated product where glass fiber is used.

2.2 ACCESSORIES

A. Insulation supports: Corrugated cardboard for overhead installation: 100% recycled content.

2.3 SOURCE QUALITY CONTROL

A. Recyclability: Project goal is to provide products that are [100] percent recyclable.

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. Installer shall recycle scrap insulation.

3.2 PREPARATION *(NOTE 1.7).*

A. Construction debris shall be removed from spaces to be insulated. *(Note 1.8)*

B. Leaks in the walls, floors, or ceiling shall be sealed with sealant to stop air infiltration.

C. Ensure that edges around windows and doors are adequately sealed to prevent air infiltration.

D. Gaps around pipes and ducts penetrating walls or ceiling shall be sealed.

3.3 INSTALLATION *(SEE NOTE 1.9)*

A. Install insulation that is dry and free of damage. *(Note 1.9a).*

B. All building insulation shall be protected from high humidity conditions. In cases where glass fiber will dry naturally and regain its original R-value, insulation shall be allowed to dry thoroughly. Under conditions where the insulation will not dry thoroughly insulation shall be replaced. *(Note 1.9a).*

C. Insulation shall be isolated from interior space by installing a continuous layer of impervious material (air-barrier) between the insulation and the living space. *(Note 1.9b).*

D. Unfaced building insulation shall not be installed in an exposed location/surface where it will be subject to human contact. *(Note 1.9b).*

E. If new material is being added to insulation already in place, batts with no vapor retarders attached to it shall be used. In case such a product is unavailable the vapor retarder facing between layers of insulation shall be removed. *(See Note 1.9c).*

F. Insulation shall be installed snugly between framing members, leaving no gaps between framing members. *(Note 1.9d).*

G. Insulation shall be cut to butt-fit around obstructions and penetrations, or the insulation shall be cut to the middle of the batt's thickness and one flap shall be under the wire/pipe and the other over the wire/pipe. Insulation shall not be compressed to fit behind pipes or wires. *(Note 1.9e).*

H. Bridging or cross bracing of ceiling or floor joists shall be insulated by splitting a batt vertically at the center and packing one half into the lower opening and the other half into the upper opening.

I. Junction boxes for wall switches and convenience outlets at outside walls shall be insulated between the rear of the box and the sheathing. Insulation shall be placed behind the junction box and if necessary, insulation shall be cut to fit snugly around it.

J. Insulation shall be placed between the piping in exterior walls and the exterior wall sheathing. Sidewalls where plumbing fixtures are to be placed shall be insulated before the fixtures are installed.

K. Insulation shall not be installed on a suspended ceiling with removable ceiling panels.

L. Wood-framed wall:

1. For cold or mild climates: The vapor retarder shall be installed on the surface that is in contact with the interior space. *(Note 1.9f).*
2. For hot and humid climates: The vapor retarder should be installed facing the exterior. *(Note 1.9f).*
3. For glass fiber insulation with facing, flanges shall be stapled either to the faces or sides of the studs. Flanges shall be pulled taut and stapled such that there are no gaps between the stapling surface and the flanges through the entire length of the insulation. The flange of the faced insulation placed in the next cavity shall overlap the previously stapled flange.
4. Unfaced rigid fit insulation shall be pressure fitted between studs.
5. Additional strips of insulation shall be cut and installed to fill all gaps around window and doorframes, without compressing the insulation.
6. Pieces of insulation shall be installed (without compressing the insulation) in small spaces between studs at the corners of buildings and at intersections of partitions and sidewalls before sheathing is applied.
7. Non-standard-width framed spaces shall be insulated by cutting the insulation and facing about an inch wider than the space to be filled. The uncut flange shall be stapled as usual. The facing on the cut side shall be pulled to the other stud and stapled through the vapor retarder to the stud.

M. Metal-framed wall:

1. For cold or mild climates: The vapor retarder shall be installed on the surface that is in contact with the interior space. *(Note 1.9f).*
2. For hot and humid climates: The vapor retarder should be installed facing the exterior. *(Note 1.9f).*
3. A single batt whose length is equivalent to the distance between the studs should be used in sidewalls. When more than one batt is used, pieces shall be snugly butted.
4. Glass fiber batt insulation shall be friction fitted into stud cavities. Stapling flanges shall be left folded when faced insulation is used. The interior wall shall be applied after the friction fit installation to complete the installation procedure.

(*Note 1.9g).*

5. A layer of insulation sheathing shall be installed, in addition to batt insulation. *(Note 1.9h).* [Optional-Edit as per project]
6. Steel frames shall be wrapped with rigid foam insulation caps. *(Note 1.9h).* [Optional-Edit as per project].
7. Additional strips of insulation shall be cut and installed to fill all gaps around window and door frames.
8. Pieces of insulation shall be installed in small spaces between studs at the corners of buildings and at intersections of partitions and sidewalls before sheathing is applied.

N. Wood-framed ceiling:
1. Faced insulation shall be placed between joists with the vapor retarder facing down. If insulation is installed before ceiling finish flanges shall be stapled to bottom faces or sides of joists.
2. Non-standard-width framed spaces shall be insulated by cutting the insulation and facing about an inch wider than the space to be filled. The uncut flange shall be stapled as usual. The facing on the cut side shall be pulled to the other stud and stapled through the vapor retarder to the stud.
3. Install unfaced batt insulation in warm, humid climates. [Optional – Edit as per location of project].
4. If the existing insulation is near or above the top of the joists, the new batts shall be placed perpendicular to the old ones. *(Note 1.9i).*
5. All deep drops and interior wall cavities shall be covered by an impervious layer to keep insulation in place and stop air movement.

O. Floor Joists:
1. Faced insulation shall be used with the vapor retarder facing up.
2. Where the insulation is less than the thickness of the joists and the method of installation does not hold the insulation up against the sub flooring, the headers or band joists at outside walls shall also be insulated. *(Note 1.9j).*

P. Cathedral Ceilings:
1. A ventilation space of at least [one inch] shall be left between the insulation and the roof.
2. Prior to installation, a ventilation baffle shall be installed at the eave of every joist if high-density insulation that can maintain the required ventilation space is used. Alternately, ventilation baffles shall be installed along the entire run of each rafter cavity. *(Note 1.9k).*
3. Faced insulation shall be installed with vapor retarder facing down, and stapled between the rafters. Staples shall not be secured to the inside face of the rafter. The flange of the faced insulation placed in the next cavity shall overlap the previously stapled flange.
4. Non-standard-width framed spaces shall be insulated by cutting the insulation and facing about an inch wider than the space to be filled. The uncut flange shall be stapled as usual. The facing on the cut side shall be pulled to the other stud and stapled through the vapor retarder to the stud.
5. If unfaced insulation is used in cathedral ceilings, a separate vapor retarder shall be installed. When vents at both eaves and ridge are not provided, a high-

performance vapor retarder, such as polyethylene, shall be used in northern locations. (Polyethylene can be used with either faced or unfaced insulation.)

Q. Metal-framed ceiling:

1. Unfaced glass fiber batt insulation shall be friction fitted into stud cavities. Stapling flanges shall be left folded when faced insulation is used. The ceiling shall be applied to complete the friction fit installation.
2. Ventilation and vapor retarder requirements shall be the same as with wood framing.

R. Underside of framed roof

1. Faced insulation shall be installed with the vapor retarder facing down in colder climates. *(Note 1.9f).*
2. Ventilation and vapor retarder requirements are the same as with wood framing.

S. Metal deck

1. Seams between batts shall be sealed to complete the vapor barrier.

3.4 FIELD QUALITY CONTROL

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved insulation material is used and installed as per specifications, after the preparation stage, and prior to covering insulation with interior finish. *(Note 1.10).*

3.5 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess materials as required by the construction waste management program, section 01565.

END OF SECTION

SECTION 07211 - GLASS FIBER BATT BUILDING INSULATION – NOTES

JUSTIFICATION

1.1 Insulation reduces energy consumption in a building.

1.2 Glass fiber is extremely durable and can outlast the life of the building. It can be reused or recycled when installed properly. The inorganic nature of the substance does not promote the growth of bacteria, mold, fungi and other organisms that can cause indoor air quality concerns.

1.3 Bi-component glass fiber is less friable than standard glass fiber. Less friable fibers of bi-component glass fiber lower possibility of inhaling loose fibers or skin irritation during the installation process. It is also free of added color or binder. Choosing products free of formaldehyde, reduces indoor air quality concerns.

1.4 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

1.5 While the production process is energy intensive, high-recycled content and associated energy benefits can offset the environmental impact during the production process. Glass fiber that recycles post-consumer material uses less energy in the manufacturing process, than one that does not use any. Recycling insulation also removes a significant amount of material from the solid waste stream, and helps in reducing toxicity in the land and relieves pressure from urban landfills. Glass fiber batts can be reused and recycled into loose-fill insulation using “The Big Green Machine”.

1.6 Formaldehyde-free insulation is a critical factor in improving indoor air quality.

1.7 Meticulous preparation prior to installation to seal all visible gaps, potential leakages or openings in the surfaces where insulation will be installed reduces air infiltration. Air infiltration can introduce moisture and reduce thermal performance of glass fiber insulation.

1.8 Ensure that surfaces are clean before installing insulation since presence of debris on the insulation affects thermal performance.

1.9 Proper installation is the key to getting the rated performance of glass fiber batts and desirable indoor air quality. Proper installation ensures durability and enables reuse of the product. Scraps of glass fiber batt insulation can be recycled to produce loose-fill insulation, when installed as per specifications.

a. Moisture penetration can cause structural damage and adversely affect the thermal performance of glass fiber insulation. Installing dry insulation and following the specified installation technique prevent moisture penetration.

b. Isolating the insulation from living areas and supply air paths ensures that glass fibers (a probable carcinogen) stay out of the living area air-stream.

c. When more than one layer of insulation is installed, having more than one layer of vapor retarder would trap any existing moisture between the two layers of vapor retarder and prevent it from drying out. As discussed

NOTES

earlier, this would reduce the intended thermal performance of the insulation.

d. Air gaps left in insulated cavities reduce thermal performance of insulation.

e. Incorrect installation procedure, such as compressing the batt and continuous contact to surfaces with temperatures below freezing, reduces overall R-value.

f. Check local code for appropriate orientation or use of vapor barrier. The orientation of the vapor retarder is critical to avoid moisture deposition.

g. Ensure that batts are constrained by studs at their edges and by wall facings front and rear, since air gaps adversely affect R-Value.

h. For highly conductive framing systems installing a layer of insulating sheathing minimizes the effect of thermal bridging. If it is not possible to install a layer of sheathing, wrapping insulation, typically rigid foam, around the steel frame can also reduce the effect of thermal bridging and increase the depth of the cavity for installing insulation (making it possible to install a thicker batt with a higher R-value).

i. Placing a new layer of batt insulation perpendicular to the old one on top of the joists in wood-framed ceiling covers the tops of the joists and reduces heat loss or gain through the frame.

j. The air space between the top of the insulation and the sub-floor will allow heat to be lost at outside walls, unless the headers/band joists are insulated as well.

k. Check local code for ventilation space requirement.

1.10 Commissioning agent should verify the following by doing spot checks at various locations in the ceiling and walls:

a. Ensure that insulation is isolated from living areas to prior to installing insulation by checking wall, floor and ceiling surfaces, for potential leakages before insulation is installed. Check to see if tops of interior wall cavities, areas above staircases and dropped ceilings, are adequately sealed by wrapping a plastic sheet that will effectively prevent insulation from dropping/sagging into these cavities. Check to see that edges around windows, doors and gaps around pipes and ducts are adequately sealed, before insulation is installed.

b. Metal accessories shall be inspected for signs of corrosion prior to installing insulation, and replaced if necessary.

c. Do spot checks to ensure that insulation is not damp or damaged and meets the specified R-value.

d. Lift insulation at a few spots to ensure that there is not a significant amount of debris on the insulated surface or the insulation.

e. Verify that insulation is properly isolated from living areas by using an impervious barrier and unfaced insulation is not installed in areas where it will be easily subject to human contact.

f. Check to see that vapor retarder has been removed from additional layer

NOTES

of insulation when more than one layer is installed.

g. When installed between framed-members, insulation shall be inspected prior to covering to verify if installation meets the standards as specified in the installation procedure.
   1) Insulation is not compressed behind pipes and other penetrations, packed around window, split and wrapped around joists and pipes etc.
   2) There is no air gap between pieces of batt insulation when more than one batt is used between framing members.
   3) Faced insulation is stapled as per specifications (without gaps, on the specified side of the joists etc.)
   4) Do spot checks to see that insulation is installed in corners and intersections of exterior walls.

h. Do spot check to verify that vapor-retarder faces specified direction.

i. Inspect cathedral ceiling prior to installing insulation to verify installation of ventilation baffles as per specifications.

APPLICATION

2.1 Wall, ceiling and floor cavity insulation.

2.2 Continuous insulation under roof or floor.

2.3 Wood or metal frame.

COST IMPACT

3.1 Detailed installation practices could cost more.

3.2 Installation cost of less than $0.30 to $0.50 per square foot of R-19 installed.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Glass fiber batt

a. Miraflex (non-offgassing, less toxic glass fiber insulating material with 30% post-consumer recycled content) and PinkPlus by Owens Corning. http:// www.owenscorning.com

b. CertainTeed, EasyHandler (fiber batt insulation with polypropylene wrap) by CertainTeed Inc. http:// www.certainteed.com

c. Grid shield Rx by Schuller Inc.

d. "Comfort Therm", "Thermal-SHIELD" and "Goldline" (glass fiber batt insulation with 25% recycled glass) by John Manville, http:// www.jm.com

4.2 Accessories

a. Snap-Cap by U.S. Building Technology. This technology optimizes the use of rigid insulating foam, by placing it on the framing members only (the studs, the plates, and the headers). The Snap-Cap product employs a friction-fit insulation design that snaps onto the framing members during the normal construction process. The rigid foam insulates the framing and deepens the wall cavity, which improves the overall thermal performance of the wall by reducing the effect of thermal bridging and making it

NOTES

possible to install a thicker batt than would be possible with the existing frame size.

b. Snap-Cap can be installed on the exterior, interior, or both surfaces of the wall assembly. USBT and Snap-Cap are trademarks of the United States Building Technology Inc., 1 Rice Street, Suite #1, Natick, MA 01760, USA.

c. Raft-R-Mate® attic rafter vents by Owens Corning. RAFT-R-MATE® attic rafter vents create a space between each rafter for air to flow freely up the rafters and into the attic. Owens Corning RAFT-R-MATE Attic Rafter Vents are made of extruded polystyrene. http://www.owenscorning.com/around/ventilation/raftrmate_attic.asp

4.3 Recycling

Don Smith,
Big Green Marketing,
PO Box 510,Bend,
OR 97709,
503/383-0095.

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 Demkin, J. A. 1997. Environmental Resource Guide. John Wiley and Sons. New York. (Environmental and indoor air quality issues during manufacture and installation of glass fiber insulation products).

5.3 Environmental Building News. Volume 3, Number 2. p 5. (Recycling fiberglass insulation scraps).

5.4 Wilson, A. 1995. Environmental Building News. Vol. 4. Number 1. p.1 & pp. 11-17 (Environmental and indoor air quality issues during manufacture and installation of insulation products).

5.5 Zaloudek, J. 1995. Environmental Building News. Vol. 4. Number 1. pp. 8-9. (Environmental and health-related benefits of Miraflex by Owens Corning).

5.6 EBN. 1997. Environmental Building News. Vol. 6. Number 9. p. 9. (Accessory for wrapping steel framing).

5.7 EBN. 1996. Environmental Building News. Vol. 5. Number 6. pp. 9 – 10. (Environmental and health-related benefits of Grid-SHIELD Rx by Schuller Inc. and CertainTeed by CertainTeed Corporation).

5.8 North American Insulation Manufacturer's Association. http://www.naima.org/ (Environmental and health-related benefits of glass fiber, scheduling, installation and applicable standards).

RELATED SPECIFICATION SECTIONS

6.1 07212 Mineral Wool Batt Building Insulation

6.2 07213 Cellulose Spray (Loose) Building Insulation

NOTES

6.3 07214 Glass Fiber Blown-in Building Insulation
6.4 07215 Mineral Wool Blown-in Building Insulation
6.5 07216 Cellulose Spray (Wall Cavity) Insulation
6.6 07217 Foam Board Building Insulation
6.7 07218 Radiant Barrier Building Insulation
6.8 07220 Roof and Deck Insulation
6.9 07240 Exterior Insulating Finish System (EIFS)
6.10 07300 Shingles, Roof Tiles and Roof Coverings
6.11 07500 Membrane Roofing
6.12 07610 Sheet Metal Roofing
6.13 07814 Cementitious Fireproofing

SECTION 07212 – MINERAL WOOL BATT BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.2 SYSTEM DESCRIPTION

A. Mineral wool batt insulation installed in [wall cavity] [ceiling cavity] [roof] to meet the required thermal performance. *(Note 1.2)*.

1.3 SUBMITTALS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.6 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Mineral wool batt insulation.

B. Performance Requirements:
   1. Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.2).*
   2. Roof: Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.2).*

C. Recycled content: Minimum 75% post industrial for mineral wool core.

D. Product shall emit no formaldehyde when tested per § 01350.

2.2 ACCESSORIES

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

2.3 SOURCE QUALITY CONTROL

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

3.2 PREPARATION

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

3.3 INSTALLATION

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

3.4 FIELD QUALITY CONTROL

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

3.5 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

N
O
T
E
S

SECTION 07212 – MINERAL WOOL BATT BUILDING INSULATION – NOTES

See also Section 07211 - Glass Fiber Batt Building Insulation.

JUSTIFICATION

1.1 Insulation reduces energy consumption in buildings. Mineral wool batts can be reused and recycled effectively. While the production process is energy intensive, its energy benefits can effectively offset the environmental impact during the production process. Mineral wool has a high-recycled content and removes waste from the solid waste stream.

1.2 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

APPLICABILITY

2.1 Wall, ceiling and floor cavity insulation

2.2 Continuous insulation under roof or floor.

2.3 Wood or metal frame.

COST IMPACT

3.1 Detailed installation practices may cost more.

3.2 Installation cost of less than $.50 per square foot of R-19 installed.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Mineral Wool insulation made from volcanic rock and recycled steel slag by Roxul, Inc.

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 Demkin, J. A. 1997. Environmental Resource Guide. John Wiley and Sons. New York. (Environmental and indoor air quality issues during manufacture and installation of mineral wool insulation products).

5.3 Wilson, A. 1995. Environmental Building News. Vol. 4. Number 1. p.1 & pp. 11-17 (Environmental and indoor air quality issues during manufacture and installation of insulation products).

5.4 http://www.naima.org/ (Properties, applicable standards and installation)

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass Fiber Batt Building Insulation

6.2 07213 Cellulose Spray (Loose) Building Insulation

NOTES

6.3 07214 Glass Fiber Blown-in Building Insulation
6.4 07215 Mineral Wool Blown-in Building Insulation
6.5 07216 Cellulose Spray (Wall Cavity) Insulation
6.6 07217 Foam Board Building Insulation
6.7 07218 Radiant Barrier Building Insulation
6.8 07220 Roof and Deck Insulation
6.9 07240 Exterior Insulating Finish System (EIFS)
6.10 07300 Shingles, Roof Tiles and Roof Coverings
6.11 07500 Membrane Roofing
6.12 07610 Sheet Metal Roofing
6.13 07814 Cementitious Fireproofing

SECTION 07213 – CELLULOSE SPRAY (LOOSE) BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.2 SYSTEM DESCRIPTION

A. Cellulose loose-fill insulation installed in [wall cavity] [ceiling cavity] to meet the required thermal performance. *(Note 1.3)*.

1.3 SUBMITTALS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.6 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Cellulose loose-fill insulation complying with the performance requirements of ASTM C 739, "Industry Standard Loose-fill cellulose insulation for Thermal Insulation”.

B. Use cellulose manufactured using the fiberization process. [Optional – Edit as per project] *(Note 1.2).*

C. Performance Requirements:

1. Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.3).*
2. Roof: Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.3).*

D. Recycled content: Minimum 75% post-consumer recycled content. *(Note 1.4).*

E. Product shall emit no VOCs. *(Note 1.5)*

2.2 SOURCE QUALITY CONTROL

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

3.2 PREPARATION *(NOTE 1.6).*

A. Construction debris shall be removed from spaces to be insulated.

B. Wood studs shall be examined for moisture content. They shall not exceed 19% moisture content at the time of installation.

C. Installer shall inspect external siding of existing building for peeling paint, mildew, fungi and other such indicators of moisture problems and rectify them.

D. Installer shall inspect the interior walls for weak spots that may not be able to withstand pressures during the filling operation, and shall reinforce them. Alternately, the installer shall use less pressure when filling such areas.

E. Installer shall check for holes in ceilings or sidewalls that would allow insulation to escape, and seal them.

F. Installer shall seal walls that go into basements or crawl spaces.

G. Installer shall inspect walls with alterations (such as built-in bookshelves and cabinets) for isolated cavities, and make separate entry holes for these cavities.

H. Installer shall not fill wall cavities that are used as air ducts for HVAC systems.

I. Installer shall place blocking around openings in heating or air-conditioning systems, in insulated areas, without restricting airflow.

J. Hard covers shall be placed over all deep drops and interior wall cavities to keep insulation in place and stop air-movement.

K. Small inaccessible openings shall be filled with pieces of batt insulation.

L. All potential gaps for air infiltration or leakage such as, missing electrical plates or loose fitting moldings, shall be replaced and or caulked from inside to prevent infiltration of cellulose dust into the living space through these leakages.

M. All voids around windows and doors shall be sealed with urethane foam or similar material to stop air infiltration. Expanding foams shall not be used around windows or doors.

N. All vertical plumbing and electrical penetrations shall be sealed through both top and bottom plates of all walls.

O. The open side of any wall between a heated and unheated area shall be covered by backer board to form a cavity for retaining loose fill material.

3.3 INSTALLATION *(NOTE 1.7)*

A. Dry and undamaged insulation shall be installed.

B. Installer shall comply with manufacturer's coverage specifications. The bag count and the weight per square foot requirements of the coverage chart shall be adhered to. *(Note 1.8)*

C. The minimum thickness of the insulating layer shall be equal to the thickness as specified in the product label before settling has occurred. *(Note 1.8)*

D. The insulation shall be blown in the direction of the joists and not across them.

E. Insulation shall go underneath and on both sides of the obstruction such as cross bracing and wiring.

F. Wall or ceiling cavity shall be completely filled up with insulation.

G. Cold air returns or combustion air intakes for hot air furnaces shall not be blocked or insulation shall not be installed in a manner that would allow it to be drawn into the system.

H. Areas under any plywood platform or walks for HVAC equipment installation and access shall be pressure-filled with insulation, unless appropriate batt insulation has already been installed.

I. Rigid foam or batt insulation (that is equal to or exceeds the R-Value of the insulation on the ceiling) shall be permanently attached to the access panels and doors using adhesive or mechanical fastener.

J. Vapor retarder:

1. For cold or mild climates: The vapor retarder shall be installed on the wall that is in contact with the interior space. *(Note 1.9)*
2. For hot and humid climates: The vapor retarder should be installed on the wall that is in contact with the exterior. *(Note 1.9)*

3.4 FIELD QUALITY CONTROL

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved insulation material is used and installed as per specifications after the preparation stage, and before the insulation is covered with interior finish. *(Note 1.10)*

3.5 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

NOTES

SECTION 07213 – CELLULOSE SPRAY (LOOSE) BUILDING INSULATION – NOTES

See also notes for Section 07211 - Glass Fiber Batt Building Insulation.

JUSTIFICATION

1.1 Insulating a building reduces heating and cooling loads. Cellulose products are less susceptible to depreciation in effective R-Value in extreme cold conditions and can be installed with maximum efficiency even in very cold climates (unlike glass fiber or mineral wool insulation products). High recycled content, low production energy and localized production (low transportation energy) makes cellulose the insulation product with the lowest embodied energy, and relatively low environmental impact.

1.2 The fiberization process produces cellulose with less dust and lower density compared to conventional cellulose of equivalent R-value. Lower dust content is preferred for indoor air quality. Low-density cellulose uses less material and helps in conserving resources.

1.3 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

1.4 Cellulose insulation is largely made up of recycled paper. High recycled content and bio-degradable components (except for chemicals added for fire retardancy and pest control) makes cellulose fiber insulation one of the most environmentally friendly insulation products. High recycled content removes a huge amount of material from the solid waste stream and also conserves landfill areas.

1.5 Cellulose consists mostly of bio-degradable components (except for chemicals added for fire retardancy and pest control). Minimal VOC content in the added chemicals, ensures good indoor air quality.

1.6 Meticulous preparation such as using vapor barriers, air barriers, tape, caulking, injecting foam sealant, overlapping foam sheathing etc., prior to installation reduces air exfiltration and moisture penetration, which adversely affects thermal performance and can promote undesirable conditions like bacterial growth, mildew, fungi, mold etc. Moisture deposition can also cause rotting of structural wood. Sealing potential leakage spots, and isolating cellulose insulation from HVAC ducts ensures that cellulose stays out of the living area air stream. Removing construction debris from the site ensures that the thermal performance of the insulation will not be affected after installation.

1.7 Proper installation procedure ensures that the expected thermal performance is achieved, and increases reusability potential of the material. Installing dry insulation is one of the ways of ensuring that moisture related problems won't occur. Proper installation ensures that the insulation is completely protected from high humidity, or exposure to extreme temperatures that can decompose chemicals added for fire retardancy, pest control etc. Proper installation is also critical in isolating cellulose dust (indoor air quality issue) from the living spaces.

1.8 The R-value of cellulose is dependant on the settled thickness of the material (as

NOTES

the material has a tendency to settle over a period of time), and uniformity of thickness over the surface. Adhering to the manufacturer's coverage specifications ensures that the recommended amount of insulation to provide the rated R-value is met.

1.9 Check local code for appropriate orientation or use of vapor barrier. The orientation of the vapor retarder is critical to avoid moisture deposition.

1.10 Commissioning agent should verify the following by doing spot checks at various locations in the ceilings and walls:

a. Commissioning agent shall examine wood studs and surfaces for signs of moisture such as mildew, peeling paint etc, and weak spots prior to installation. Installation shall not be completed until undesirable conditions have been rectified.

b. Commissioning agent shall do spot checks prior to installing insulation to check if all possible avenues for insulation to escape have been adequately sealed, and all heat producing devices have been appropriately isolated.

c. Commissioning agent shall do spot checks prior to installation of insulation in new construction to ensure that ventilation access has been provided as per specifications, small cavities around doors and windows have been insulated, blocking has been installed in prescribed areas, and areas in roofs that will become inaccessible after interior finish has been applied are insulated as per specifications.

d. Work shall be inspected prior to installation of insulation in existing construction to ensure that ventilation access has been provided as per specifications (by installing baffles).

e. Commissioning agent shall do a few spot checks to ensure that insulation covers entire surface, and uniformly at appropriate depth. Commissioning agent shall consider using an infrared scanner to ensure installed density meets specifications

f. Access panels and covers shall be inspected for appropriate insulation.

g. Material shall be completely dry before vapor retarders, foil and vinyl wall covering etc. are installed. Suitable electronic meters shall be used to ensure that the material is completely dry.

APPLICABILITY

2.1 Sealed cavities of walls of existing and new sidewalls and ceiling cavities.

2.2 Applicable only within specific temperature and humidity conditions.

2.3 Cannot be applied to access doors and panels.

COST IMPACT

3.1 For the same R-value, cellulose may save 20-40% more energy due to its capacity to stop air-infiltration.

3.2 Material cost: $0.08 per R-Value per square foot

3.3 Installed cost: $0.12 per R-Value per square foot

N O T E S

3.4 However, costs vary from region to region.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 “Therm-x,” “R-Pro,” “R-Pro Plus”, “Energy Wise” and “CF” by Greenstone Industries/ Louisiana Pacific Corp. http://www.lpcorp.com

4.2 Wall-guard by CellPak. http://www.cellpak.com

REFERENCES FOR MORE INFORMATION

5.1 http://www.energyca.gov/efficiency/quality homes/insulation.html. (Installation and applicable standards).

5.2 http://www.cellulose.org/crs.htm. (Applicable standards and code regulations).

5.3 http://www.cellulose.org/consumer.htm. (Consumer Information).

5.4 http://www.cellulose.org/builder.htm. (Environmental and safety issues, applicable standards and code regulations).

5.5 http://www.cellulose.org/specs.htm. (Technical Specifications).

5.6 http://www.cellulose.org/fire-safe.htm. (Fire-safety issues).

5.7 California Energy Commission. 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.8 Wilson, A. 1993. Environmental Building News. Vol. 2. Number 5. p.1 & pp. 12-17 (Environmental and indoor air quality issues during manufacture and installation of cellulose products).

5.9 Wilson, A. 1995. Environmental Building News. Vol. 4. Number 1. p.1 & pp. 11-17 (Environmental and indoor air quality issues during manufacture and installation of cellulose products).

5.10 CIMA, Cellulose Insulation: codes, regulations and specifications, CIMA Technical bulletin #1. Dayton, OH

5.11 CIMA, Consumer Update Insulation Effectiveness Bulletin, CIMA Technical bulletin #4. Dayton, OH (Cellulose versus glass fiber)

5.12 http://www.cellulose.org/practice.htm. (Installation procedure).

5.13 Demkin, J. A. 1997. Environmental Resource Guide. John Wiley and Sons. New York. (Environmental and indoor air quality issues during manufacture and installation of cellulose insulation products).

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass Fiber Batt Building Insulation

6.2 07212 Mineral Wool Batt Building Insulation

6.3 07214 Glass Fiber Blown-in Building Insulation

6.4 07215 Mineral Wool Blown-in Building Insulation

6.5 07216 Cellulose Spray (Wall Cavity) Insulation

6.6 07217 Foam Board Building Insulation

NOTES

6.7 07218 Radiant Barrier Building Insulation

6.8 07220 Roof and Deck Insulation.

6.9 07240 Exterior Insulating Finish System (EIFS)

6.10 07300 Shingles, Roof Tiles and Roof Coverings

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

SECTION 07214 – GLASS FIBER (BLOWN-IN) BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.2 SYSTEM DESCRIPTION

A. Glass fiber loose-fill insulation installed in [wall cavity] [ceiling cavity] to meet required thermal performance. *(Note 1.1)*.

1.3 SUBMITTALS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.6 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Loose-fill glass fiber insulation complying with the performance requirements of ASTM C 764, "Standard Specification for Mineral Fiber Loose-Fill Thermal Insulation”. *(Note 1.1)*

B. Performance Requirements:
   1. Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.2)*
   2. Roof: Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.2)*
   3. Recycled content: Minimum 18% post consumer, 7% post industrial (25% total) for glass fiber core. *(Note 1.3)*

C. Product shall emit no VOCs.

2.2 SOURCE QUALITY CONTROL

A. [See Section 07211 - Glass Fiber Batt Building Insulation].

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

3.2 PREPARATION

A. [See Section 07213 – Cellulose Spray (Loose) Building Insulation]

3.3 INSTALLATION

A. [See Section 07213 – Cellulose Spray (Loose) Building Insulation]

3.4 FIELD QUALITY CONTROL

A. [See Section 07213 – Cellulose Spray (Loose) Building Insulation]

3.5 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

NOTES

SECTION 07214 – GLASS FIBER (BLOWN-IN) BUILDING INSULATION – NOTES

See also notes for Section 07211 - Glass Fiber Batt Building Insulation and Section 07213 – Cellulose Spray (Loose) Building Insulation.

JUSTIFICATION

1.1 ASTM C-764 covers material attributes such as, density, thermal resistance, surface burning characteristics, adhesive/cohesive strength, smoldering combustion, fungi resistance, corrosion, moisture vapor absorption, odor, and flame resistance permanency.

1.2 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

1.3 Recycled content reduces waste from the solid waste stream and uses less energy during the production process.

APPLICABILITY

2.1 [See notes for Section 07213 – Cellulose Spray (Loose) Building Insulation]

COST IMPACT

3.1 Material cost: $0.11 for glass fiber (per R-Value per square foot).

3.2 Installed cost: $0.13 for glass fiber (per R-Value per square foot).

3.3 However, costs vary from region to region.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 InsulSafe®4 by CertainTeed. http://www.certainteed.com/

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 Demkin, J. A. 1997. Environmental Resource Guide. John Wiley and Sons. New York. (Environmental and indoor air quality issues during manufacture and installation of glass fiber insulation products).

5.3 Wilson, A. 1995. Environmental Building News. Vol. 4. Number 1. p.1 & pp. 11-17 (Environmental and indoor air quality issues during manufacture and installation of insulation products).

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass Fiber wool Batt Building Insulation

6.2 07212 Mineral Wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

NOTES

6.4 07215 Mineral Wool Blown-in Building Insulation

6.5 07216 Cellulose Spray (Wall Cavity) Insulation

6.6 07217 Foam Board Building Insulation

6.7 07218 Radiant Barrier Building Insulation

6.8 07220 Roof and Deck Insulation.

6.9 07240 Exterior Insulating Finish System (EIFS)

6.10 07300 Shingles, Roof Tiles and Roof Coverings

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

SECTION 07215 – MINERAL WOOL (BLOWN-IN) BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.2 SYSTEM DESCRIPTION

A. Mineral wool loose-fill insulation installed in [wall cavity] [ceiling cavity] to meet required thermal performance. *(Note 1.1)*.

1.3 SUBMITTALS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.6 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Loose-fill mineral wool insulation complying with the performance requirements of ASTM C 764, "Standard Specification for Mineral Fiber Loose-Fill Thermal Insulation". *(Note 1.1)*

B. Performance Requirements:

1. Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.2)*.
2. Roof: Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.2)*.

C. Recycled content: Minimum 75% post industrial for mineral wool core.

D. Product shall emit no formaldehyde when tested per § 01350.

2.2 SOURCE QUALITY CONTROL

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

3.2 PREPARATION

A. [See Section 07213 – Cellulose Spray (Loose) Building Insulation]

3.3 INSTALLATION

A. [See Section 07213 – Cellulose Spray (Loose) Building Insulation]

3.4 FIELD QUALITY CONTROL

A. [See Section 07213 – Cellulose Spray (Loose) Building Insulation]

3.5 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

NOTES

SECTION 07215 – MINERAL WOOL (BLOWN-IN) BUILDING INSULATION – NOTES

See also notes for Section 07211 - Glass Fiber Batt Building Insulation, Section 07212 – Mineral Wool Batt Building Insulation and Section 07213 – Cellulose Spray (Loose) Building Insulation.

JUSTIFICATION

1.1 ASTM C-764 covers material attributes such as, density, thermal resistance, surface burning characteristics, adhesive/cohesive strength, smoldering combustion, fungi resistance, corrosion, moisture vapor absorption, odor, and flame resistance permanency.

1.2 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

APPLICABILITY

2.1 [See notes for Section 07213 – Cellulose Spray (Loose) Building Insulation.]

COST IMPACT

3.1 Installation cost of less than $.50 per square foot of R-19 installed.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 "Enviroguard Gold" and "E.G. 2000," by American Rockwool, Inc. http://www.amerrock.com/

4.2 “Premium™ Blowing Wool,” by FIBREX, Inc. http://www.fibrex.on.ca/

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 Demkin, J. A. 1997. Environmental Resource Guide. John Wiley and Sons. New York. (Environmental and indoor air quality issues during manufacture and installation of glass fiber insulation products).

5.3 Wilson, A. 1995. Environmental Building News. Vol. 4. Number 1. p.1 & pp. 11-17 (Environmental and indoor air quality issues during manufacture and installation of insulation products).

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass fiber wool Batt Building Insulation

6.2 07212 Mineral wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

6.4 07214 Glass Fiber Blown-in Building Insulation

6.5 07216 Cellulose Spray (Wall Cavity) Insulation

N
O
T
E
S

6.6 07217 Foam Board Building Insulation

6.7 07218 Radiant Barrier Building Insulation

6.8 07220 Roof and Deck Insulation

6.9 07240 Exterior Insulating Finish System (EIFS)

6.10 07300 Shingles, Roof Tiles and Roof Coverings

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

SECTION 07216 – CELLULOSE SPRAY (WALL CAVITY) BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See also Section 07211 - Glass Fiber Batt Building Insulation]

B. Overspray – Portion of the material from a spray pattern not filling or adhering to intended substrates.

C. Dry-weight – Weight of water divided by weight of dry cellulose*. (Note 1.1)*.

1.2 SYSTEM DESCRIPTION

A. Cellulose wet spray insulation installed in [wall cavity] to meet the required thermal performance*. (Note 1.1).*

1.3 SUBMITTALS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.4 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Cellulose spray insulation complying with the performance requirements of ASTM C 1149, " Standard Specification for Self-Supported Spray Applied Cellulosic Thermal/Acoustical Insulation)". (*Note 1.2)*

B. Performance Requirements:

1. Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. (*Note 1.3)*
2. Roof: Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. (*Note 1.3)*

C. Recycled content: Minimum 50% total recycled content, 18% of which shall be post consumer recycled content. (*Note 1.4)*

D. Product shall emit no VOCs.

E. Cellulose manufactured using the fiberization process is recommended. *(Note 1.5)* [Optional].

F. Cellulose using less than 40% water on a dry-weight basis during the installation process is recommended. *(Note 1.5)*

2.2 SOURCE QUALITY CONTROL

A. Recyclability: Project goal is to recycle all overspray.

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. Installer shall recycle the overspray insulation.

3.2 PREPARATION *(NOTE 1.6)*

A. [See also Section 07213 – Cellulose Spray (Loose) Building Insulation]

B. Liquid flow tests shall be made periodically to ensure a proper liquid to fiber ratio. *(Note 1.7)*

3.3 INSTALLATION *(NOTE 1.8)*

A. Use manufacturer's specification for moisture content.

B. Each layer shall be sprayed evenly and there shall be no voids between each layer. Insulation shall be filled right up to the top. Do not overfill the cavity. The cavities under windows, soffits etc. shall be filled to the very top as well. *(Note 1.9)*

C. The cavity shall be filled to a uniform thickness. The stud shall be wiped off periodically to get an accurate idea of the actual thickness of cavity. *(Note 1.10)*

D. The excess material shall be trimmed with a wall scrubber and recycled.

E. The interior finish shall not be installed until the insulation layer has dried sufficiently (having a measured moisture content of 25% or less). *(Note 1.11)*

F. The excess material (overspray) shall be recycled. The overspray shall be consistently blended with the dry product and the proper liquid to fiber ratio ensured before spraying begins.

G. Vapor retarders:

1. For cold or mild climates: The vapor retarder shall be installed on the wall that is in contact with the interior space. *(Note 1.12).*
2. For hot and humid climates: The vapor retarder should be installed on the wall that is in contact with the exterior. *(Note 1.12).*

3.4 FIELD QUALITY CONTROL

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved insulation material is used and installed as per specifications after the preparation stage, and before the insulation is covered with interior finish. *(Note 1.13)*

3.5 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

N O T E S

SECTION 07216 – CELLULOSE SPRAY (WALL CAVITY) BUILDING INSULATION – NOTES

[See also notes for Section 07211 - Glass Fiber Batt Building Insulation, and Section 07213 – Cellulose Spray (Loose) Building Insulation]

JUSTIFICATION

1.1 Wet spray cellulose, as the name implies, has water added during installation to make it stick when blown into wall cavities (binders are sometimes used as well). Conventional wet-spray cellulose using a hammermill product is usually installed quite wet—sometimes with more than 100% water on a “dry-weight” basis (weight of water divided by weight of dry cellulose), or about four gallons of water per 30- pound bag.

1.2 ASTM C-1149 covers 10 material attributes: Density, thermal resistance, surface burning characteristics, adhesive/cohesive strength, smoldering combustion, fungi resistance, corrosion, moisture vapor absorption, odor, and flame resistance permanency. Material installed using liquid adhesive (Type I) also has substrate deflection and air erosion characteristic requirements. Under C-1149 spray-applied material is tested in the sprayed state.1.3 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

1.4 Recycling reduces material from the solid waste stream and reduces energy used during the production process. North America produces roughly 13 million tons of newspaper each year—about 100 pounds per person. Fifty-five percent of this is currently recycled (1992) according to the American Forest and Paper Association; the rest accounts for about 4.6% of municipal solid waste. While these statistics are a big improvement over ten years ago when newspaper accounted for 8% of our municipal solid waste, we still landfill or incinerate a huge amount. There are various ways old newspaper can be recycled. The biggest use, turning it back into new newspaper, requires significant processing (de-inking and bleaching, for example). Recycling newsprint to make cellulose insulation is a less energy intensive process.

1.5 A relatively new formulation of cellulose insulation, referred to as stabilized cellulose, is used in attics. This product has a binder in it and is applied with a small quantity of water. The binder prevents settling, which may otherwise reduce the installed thickness of loose-fill cellulose insulation by as much as 25%. A newer process, known as fiberization disaggregates newsprint back into individual fibers instead of cutting the paper. Fiberization produces lower density cellulose with a number of advantages. Cellulose manufactured using the fiberization process reduces the water content required during the installation process. Some products use less than 30% water during the installation process. Minimizing the amount of water used in the installation process conserves resources.

1.6 Elaborate preparation before application of wet spray cellulose helps in achieving maximum thermal benefit. Areas must be effectively sealed prior to the installation process, to reduce air infiltration. Preparing the work surfaces

NOTES

appropriately and keeping debris away from the insulation also enables recycling the overspray from the application.

1.7 A liquid flow test is extremely important to minimizing waste due to overspray. This is also crucial when the recycle method is used for spraying, as the recycled material already has a significant moisture content and is mixed with the dry insulation.

1.8 Proper installation procedure ensures that the expected thermal performance is achieved. Recommended water content, uniformity of application, and proper finishing ensures that rated thermal performance is achieved.

1.9 This ensures structural integrity of the insulation layer. Gaps would also adversely affect thermal value of the insulation.

1.10 This will help in judging the thickness of the overspray, and ensure that the insulation is sprayed to the recommended thickness.

1.11 Water content in the cellulose both before and after application affects R-value of the installed product. Moisture content is a significant concern in the wet-spray for several reasons – inadequate drying of the installed layer reduces R-value, promotes mold, mildew problems as well as structural problems.

1.12 Check local code for use and orientation of vapor barrier.

1.13 The commissioning agent shall ensure that the intent of the specifications has been met by verifying the following by doing spot checks at various locations in the walls.

a. Work shall not be accepted unless all specifications have been met.

b. Work shall be inspected at prior to the application stage to check if all leakages have been adequately sealed, and all heat producing devices have been appropriately isolated, and all drops, scuttles, braces and top plates have been covered.

c. Work shall be inspected prior to application of insulation in new construction to ensure that small cavities around doors and windows have been insulated, and areas in roofs that will become inaccessible after interior finish has been applied are insulated as per specifications.

d. Application surface and floor shall be inspected prior to application to ensure that surfaces are clean and floor has been cleared of all debris.

e. During application stage, commissioning agent shall make a few random checks to see that the proper liquid ratio is maintained.

f. Commissioning agent shall do spot checks to ensure that cavity is filled uniformly and not overfilled.

g. Commissioning agent shall verify that the insulation has dried sufficiently as per specifications before vapor retarders, foil and vinyl wall covering etc. are installed on both sides of the insulation. Suitable electronic meters shall be used to ensure that the material is completely dry.

APPLICABILITY

2.1 Wall installation other than masonry walls.

N O T E S

2.2 May not be applied to below grade or ground level walls unless specified by manufacturer's recommendations.

COST IMPACT

3.3 Using the recycle method increases labor costs as it is a more time consuming process.

3.4 Application process is more elaborate and hence more expensive than batt insulation.

3.5 Installation cost of $ 0.30 per square foot of R-19 installed.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Wall-guard by Cellpak. http://www.cellpak.com

4.2 Cocoon by Greenstone http://www.greenstone.com/index.htm

4.3 ThermoCon by ThermoCon Inc. http://www.thermocon.com/Frame.htm

4.4 Low Toxic, high thermal performance, 80% recycled fibers wet spray application by Contra Costa Insulation.

4.5 Spray-on "Celbar" and "K-13" insulation made from 75% post consumer and post industrial recycled newsprint and cardboard by International Cellulose Corp.

REFERENCES FOR MORE INFORMATION

5.1 http://www.cellulose.org/pdf/cellulose_bulletins/tech_bulletin1.pdf

5.2 California Energy Commission. 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 http://www.energyca.gov/efficiency/quality homes/insulation.html. (Installation and applicable standards).

5.2 http://www.cellulose.org.

5.3 Wilson, A. 1993. Environmental Building News. Vol. 2. Number 5. p.1 & pp. 12-17 (Environmental and indoor air quality issues during manufacture and installation of cellulose products).

5.4 CIMA, Cellulose Insulation: codes, regulations and specifications, CIMA Technical bulletin #1. Dayton, OH.

5.5 http://www.naima.org/ (Environmental and health-related benefits of fiber glass, scheduling, installation and applicable standards).

5.6 CIMA, 1998. Standard Practice for Installation of Sprayed Cellulose Wall Cavity Insulation, CIMA Technical bulletin #3. Dayton, OH.

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass Fiber Batt Building Insulation

6.2 07212 Mineral Wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

NOTES

6.5 07214 Glass Fiber Blown-in Building Insulation

6.6 07215 Mineral Wool Blown-in Building Insulation

6.7 07217 Foam Board Building Insulation

6.9 07218 Radiant Barrier Building Insulation

6.8 07220 Roof and Deck Insulation

6.9 07240 Exterior Insulating Finish System (EIFS)

6.10 07300 Shingles, Roof Tiles and Roof Coverings

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

END OF SECTION

SECTION 07217 – FOAM BOARD BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.2 SYSTEM DESCRIPTION

A. Foam board insulation installed in [walls] [roof] [floor][foundation] to meet specified thermal performance.

1.3 SUBMITTALS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See also Section 07211 - Glass Fiber Batt Building Insulation]

B. Materials shall be protected from exposure to direct sunlight using an opaque, light-colored tarp or original manufacturer's packing. Unwrapped material shall be rewrapped using an opaque, light-colored tarp or packaging. *(Note 1.3)*

1.6 SCHEDULE

A. Roofing shall be finished. Roof must be designed and constructed to drain water within 48 hours after rainfall. *(Note 1.4)*

B. Waterproofing or damp proofing shall be completely cured before applying foam board to the foundation perimeter.

C. Construction debris shall be removed from spaces to be insulated.

1.7 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: [Expanded Polystyrene] [Extruded polystyrene] [Polyisocyanurate] [Polyurethane]

B. Performance Requirements:
   1. Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.5)*
   2. Roof: Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.5)*

C. Provide products with the following recycled content. *(Note 1.6)*

1. Expanded Polystyrene: Provide product with minimum 50 percent recycled content.
2. Extruded polystyrene: Provide product with minimum 50 percent recycled content.
3. Polyisocyanurate: Provide product with minimum 9 percent recycled content.
4. Polyurethane: Provide product with minimum 5 recycled content percent.

D. Foil Facing: Provide product with minimum 80% recycled aluminum.

E. Expanding agent: Shall not contain CFCs. *(Note 1.7)*

2.2 SOURCE QUALITY CONTROL

A. Recyclability: Project goal is to provide products that are 100 percent recyclable.

PART 3 - EXECUTION

3.1 ACCEPTABLE INSTALLERS

A. [See also Section 07211 - Glass Fiber Batt Building Insulation]

3.2 PREPARATION *(NOTE 1.8)*

A. Substrate shall be flat, dry and free of honeycombs, fins or foreign material that will impede adhesive bond or damage the insulation board.

B. If siding is damaged the siding shall be removed and replaced, when installing insulation under siding.

C. If insulation is installed on steel decks after a complete tear-off or in new construction, edges shall be checked so that no edges are left unsupported along the flanges.

3.3 INSTALLATION *(NOTE 1.8)*

A. Examine product, with installer present, for manufacturer's packaging. Product shall be free of ripped back and edges.

B. Insulation shall be completely dry prior to installation.

C. Wood studs shall be examined for moisture content. They shall not exceed 19% moisture content at the time of installation.

D. Substrate shall be completely dry before installing the insulation board.

E. Substrate shall not be installed during predominantly inclement weather conditions.

F. Examine siding for damage when installing insulation in siding.

G. Foam boards shall not be used as an exposed interior finish in occupied buildings. A suitable barrier shall be installed to isolate the insulation from the interior space. Extruded Polystyrene shall not be installed where it may be in contact with surfaces whose constant temperature is in excess of 165 °F.

H. Vapor barrier shall be used as per building codes. *(Note 1.9)*

1. For cold or mild climates: Vapor retarder shall be installed in the warm in winter side of the insulation.
2. For hot and humid climates: Vapor retarder shall be facing the exterior.

I. Insulation board shall be tightly fitted/butted against each other or framing members, or sealed to provide an airtight assembly.

J. Insulation shall be cut to fit around all penetrations and projections with a maximum allowable gap of 1/4 in. Open joints shall be repaired with like insulation material.

K. Interior Foundation Wall:

1. Metal or minimum 1¼ in. treated wood furring strips shall be attached at the base of the masonry strip using common masonry fasteners.
2. In cold climates, extend over the floor / soil by 1 ft to 2 ft. Insulation shall be held in place by compressing the insulation between a wood tack strip and the sill plate.
3. Band joist area shall be filled with insulation board.

L. Exterior Foundation Walls:

1. Foam board shall be installed from the top of the footing upwards, directly over the exterior of the concrete, block or wood foundations and shall be applied to the wall using common masonry fasteners, or a recommended adhesive or both. If fasteners are used, the penetration area around the fastener shall be sealed to prevent moisture and air infiltration.
2. If the insulation board has grooved drainage channels on one face, they shall be installed against the foundation wall and connected to a foundation tile and gravel drainage system to provide protection for waterproofing and drainage of the subsurface soil moisture.
3. The backfill soil shall be placed directly in contact with the board. The board shall be in full contact with the foundation.
4. Board shall not be left exposed above the gradeline. Board shall be covered with [masonry veneer] [cementitious coatings] [siding].
5. Surrounding grade/concrete slabs shall be sloped away from foundation.

M. Wood Stud walls:

1. The foam board shall be installed vertically with seams located on studs using fasteners. If construction tape is used over joints, insulation surface shall be clean and dry before installing the tape.

N. Steel Stud Walls / Masonry Veneer:

1. 2 in. minimum clear space (or as per manufacturer’s specifications) shall be provided between the inside brick face and the exterior surface of the insulation board.
2. Insulation board joints shall be tightly fitted with tape.
3. Adequate flashings, functioning weep-holes and caulk movement joints shall be provided.

O. Furred Masonry Wall (Interior):

1. All joints shall be sealed with a suitable sealant or tape.

P. Cavity Masonry wall:

1. Joints and openings shall be sealed with tape as per manufacturer’s specifications.
2. Subsequent courses shall be installed with staggered joints.
3. 1 in. minimum clear space shall be provided between inside brick face and the

exterior surface of the insulation.

4. Adequate flashings, functioning weep holes and caulk movement joints shall be provided.

Q. Exterior Sheathing Frame System:

1. Foam board shall be installed vertically with edges tightly butted, staggered joints and interlocked board edges. Foam board joints shall not be placed over joints in the substrate. Corners shall be interlocked and board joints shall be offset a minimum of 8 in. from the corners of the fenestration openings. Nails or staples shall not be overdriven, as this will damage the insulation.
2. The seams shall be sealed with tape or caulking, to provide an airtight assembly.
3. Siding material [wood] [vinyl] [hardboard] [brick veneer] [stucco] [EIFS] [aluminum] shall be installed as per manufacturer’s instructions, as soon as possible.
4. Refer to Section 07240 – External Insulation Finish Systems.

R. Sloping roof systems:

1. Wood deck panels shall be installed with a minimum 1/8 in. gap to allow for expansion.
2. Refer Section 07500 – Membrane Roofing.

S. Mechanically fastened roof systems:

1. For mechanically fastened roof systems: The insulation shall be loosely laid or mechanically fastened to the existing roof deck.
2. [Specify for multilayer installations]: Subsequent layer of insulation shall be laid unattached over the first layer. All joints shall be staggered in relation to the underlying layer. The bottom layer shall have a minimum thickness of 2 in. and shall be at least as thick as the top layer.
3. For fully and partially adhered roofing systems or a mechanically fastened single ply membrane, a barrier board (minimum ¾ in. perlite , ½ in. wood fiber, ½ in. gypsum board etc.) shall be placed between the foam board and the roofing membrane.
4. The fasteners used to attach foamed plastic and cover board to steel deck, shall have insulation plates.
5. Installer shall ensure that the installed insulation is not exposed to sun or wind, by covering all insulation with adequate weight and an opaque membrane. *(Note 1.3)*
6. Only as much insulation that can be covered shall be laid in one day.

Refer to Section 07500 – Membrane Roofing.

T. Ballasted Protected Roof Membrane Assembly (PRMA):

1. Insulation shall be tightly butted together (unless specified otherwise by manufacturer), with rain channels facing down, over a non-degradable, bond-breaking slip-sheet as recommended by the membrane manufacturer.
2. [Specify for multilayer installations]: Subsequent layer of insulation shall be laid unattached over the first layer. All joints shall be staggered in relation to the underlying layer. The bottom layer shall have a minimum thickness of 2 in. and shall be at least as thick as the top layer.
3. A protective mat shall be placed loosely between the ballast and the insulation

(except when using pavers as ballast) perpendicular to the long dimension of the insulation board. All joints shall be lapped a minimum of 12 in.. There shall not be any end laps within 6ft of the perimeter. The fabric shall extend 2 in. – 3 in. above the stone at the perimeter and all penetrations. Wetting the fabric is helpful in holding it in place till ballast is installed.

4. [See Section 07500 – Membrane Roofing]
5. When pavers are used as ballast, supports or pedestals shall be used to support the pavers, to maintain a minimum of ½ in. air space.
6. Ballast, smooth 2 in. x 2 ft. x 2 ft. concrete pavers, water worn gravel or crushed stone shall be applied immediately to hold the system in place.

3.4 FIELD QUALITY CONTROL *(NOTE 1.11)*

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved insulation material is used and installed as per specifications after the preparation stage, and before the insulation is covered. *(Note 1.11)*

3.5 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation].

END OF SECTION

NOTES

SECTION 07217 – FOAM BOARD BUILDING INSULATION – NOTES

[See also notes for Section 07211 - Glass Fiber Batt Building Insulation]

JUSTIFICATION

1.1 Insulation reduces energy consumption in a building.

1.2 Blown foam products have the highest R-Value per inch compared to most other insulating materials. Polyisocyanurate insulation board has the highest insulation value per inch (9.0 hr. sq. ft. °F/Btu). They are useful in places where a high insulation value is required but there isn't enough space available for using other insulation products with lower R-value per inch. Foam board does not have any undesirable indoor air quality impact. It is a concern only for those with chemical sensitivity.

1.3 Foam board is susceptible to UV light and should be protected from it to ensure continued thermal performance.

1.4 Incorporating effective drainage when installed in roof ensures maximum thermal performance.

1.5 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

1.6 Products with 100% recycled content are available and recommended. Certain foam board products also recycle by-products from the chemical stream of the anti-freeze industry and by-products from the production of dimethyl-terephthalate. Recycled plastic (a material hard to recycle) is also used in the manufacture of certain foam board products. Foam board made by recycling these materials is recommended. Expanded polystyrene products can be recycled in some areas for manufacturing into new styrene products.

1.7 CFCs that were traditionally used as a blowing agent in foam boards deplete the ozone layer and must be avoided.

1.8 Careful preparation such as clean and dry substrate and product ensures that the rested thermal performance of the insulation is not affected.

1.9 Careful storage and installation are important for maximum thermal performance. Gaps, rips or tears reduce the overall R-value of the product. The presence of moisture on site or in the vicinity of the insulation also reduces effective R-value. The product is most effective when properly installed with minimal thermal breaks, air gaps, and adequately ventilated when required.

1.10 Check local code for vapor barrier use and orientation.

1.11 Commissioning agent shall so spot checks to ensure that the specifications are met:

   a. Verify that insulation and surfaces that the insulation is in contact with are dry, and free of damage.

   b. Verify that installation is installed to meet specifications when installed between framed cavity (sealed against air and moisture penetration, cut

N
O
T
E
S

around penetrations, is not exposed to the sun, joints are staggered etc.).

c. Vapor barrier faces specified orientation.

d. Verify that drainage channels face specified orientation.

APPLICABILITY

2.1 Foundation slab

2.2 Interior and exterior application for foundation walls

2.3 Wood and metal stud walls

2.4 Masonry walls

2.5 Roof applications

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 "Tuff-R 'C' " (XPS) with R-value of 8.0 per inch thickness and Thermax by Celotex Corporation. http://www.owenscorning.com

4.2 "Ener-Grid" (XPS) with 86% recycled post-consumer industrial plastic by Ener-Grid. http://www.ener-grid.com

4.3 "EPS Board" with up to 100% post industrial and post consumer recycled content by N.P.S. Corp. (NPS).

4.4 "Chemfoam" (EPS) with up to 30% post consumer and 70% post industrial recycled plastic by Pacemaker Plastics Co., Inc. http://www.pacemakerplastics.com/

4.5 "Perform Roof Insulation" (EPS) with 25% post consumer recycled plastic by Pacific Allied Products.

4.6 "RCX" (XPS) with 25% post industrial and 25% post consumer recycled plastic by Tenneco Building Products, Inc. http://www.tennecobuildingprod.com/

4.7 INSULPINK by Owens Corning. http://www.owenscorning.com

4.8 Styrofoam by Dow. http://www.dow.com

4.9 Amofoam by Tenneco (Amoco Chemical Products). http://www.tennecobuildingprod.com/

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass Fiber Batt Building Insulation

6.2 07212 Mineral Wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

NOTES

6.4 07214 Glass Fiber Blown-in Building Insulation

6.5 07215 Mineral Wool Blown-in Building Insulation

6.6 07216 Cellulose Spray (Wall Cavity) Building Insulation

6.7 07218 Radiant Barrier Building Insulation

6.8 07220 Roof and Deck Insulation.

6.9 07240 Exterior Insulating Finish System (EIFS)

6.10 07300 Shingles, Roof Tiles and Roof Coverings

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

SECTION 07218 – RADIANT BARRIER BUILDING INSULATION

PART 1 - GENERAL

1.1 DEFINITIONS

A. Emittance: The ratio of the radiant heat flux emitted by a specimen to that emitted by a black body at the same temperature and the same conditions.

B. Reflectance: Percentage of radiant energy reflected by a material.

1.2 SYSTEM DESCRIPTION

A. Radiant barrier installed to maximize thermal performance.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS: Submit the following in accordance with the requirements of Section 01350:
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Shall be stored flat on a level surface in a dry, well-ventilated building.

C. Shall be stored at temperatures and humidity conditions recommended by the manufacturer.

D. Shall be protected from dust accumulation.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Radiant barrier consisting of [one] [two] sheet/s of reflective coating applied to [one] [both] sides of substrate.
   1. Radiant barrier: [Aluminum foil laminate] [Aluminized Plastic Film] [Low-emittance coating] *(Note 1.1)*
   2. Substrate: [Kraft paper] [Plastic film] [Cardboard] [Plywood sheathing] [Air infiltration barrier material]

B. Performance requirements:
   1. Emittance: Product emittance shall be tested as per ASTM E-408 and shall not exceedan emittance of 0.10.

C. Recycled content for plastic based substrate: Minimum 50% total, a minimum of which shall be 20% post-consumer recycled content for plastic based substrate. *(Note 1.2)*

D. Product shall be free of lead or mercury additives.

E. Product shall emit no VOCs.

PART 3 - EXECUTION

3.1 PREPARATION *(NOTE 1.3.*

A. Substrate shall be totally cleaned (by washing and using an appropriate cleaner) and degreased prior to application of radiant barrier.

B. Liquid application:

1. Aluminum and galvanized steel: Corrosion shall be removed with hand tool cleaning, steel wool or other abrasive method.
2. Drywall: All cracks and nail holes shall be filled with patching paste and smooth sand. Joint components shall be cured and sanded smooth. All sanding dust shall be removed. Water stains shall be sealed with a commercial stain killer.
3. Masonry, concrete, cement brick and block: All surfaces shall be completely cured. Rough surfaces shall be filled to provide a smooth finish. New construction shall be cured for at least 28 days.
4. Plaster: Plaster shall be cured and hard. Surface shall be completely dry before application.
5. Steel: Rust and mill scale shall be removed using sand paper, steel wool, or other abrading methods. Bare steel shall be primed the same day as cleaned.
6. Wood: Exposed wood shall be sanded to a fresh wood surface. All nail holes and imperfections shall be patched with a wood filler or putty and sanded to a smooth finish.
7. Previously painted surface: All loose coatings and corrosion shall be removed. Glossy and non-porous surface shall be dulled with sandpaper. Surface shall be patched, filled and primed as requirement to have a smooth finish.

C. Surface shall be cleaned of mildew.

3.2 INSTALLATION

A. An air space shall be adjacent to the radiant barrier.

1. Double-sided radiant barrier shall have an air space on both sides.
2. One-sided radiant barrier shall have an air space adjacent to the reflective side. *(Note 1.4)*

B. When used as a vapor barrier all joints and seams shall be butted against each other and taped or overlapped and taped. *(Note 1.5)*

C. While installing a radiant barrier, existing insulation shall not be compressed. *(Note 1.6)*

D. Roof application:

1. Structural sheathing application: The reflective side of the radiant barrier shall face downward into the dropped ceiling or attic space.

2. Reinforced sheet radiant barrier material [with/without perforations]:
   a. Top of roof rafters: Radiant barrier shall be draped on top of rafters draping downward to at least 3/4 in. between the rafters to create an air space on both sides of the radiant material. Shiny side shall face down [for one-sided radiant barrier]. *(Note 1.7)*
   b. Underside of rafters: Radiant barrier shall be stapled to the underside of the rafter and draped below to maintain a minimum 3/4 in. air space on both sides of the radiant barrier. This application shall be combined with a continuous ridge-and-soffit vent system. Shiny side shall face down [for one-sided radiant barrier]. Alternately, radiant barrier shall be stretched shiny side facing down and stapled on to the sides of the rafters to maintain a minimum airspace of 3/4 in. on either side.
   c. Above roof deck: Radiant barrier shall be laid on top of roof deck with the shiny side facing up and a minimum of 3/4 in. air gap between the radiant barrier and roofing material above.

E. Wall application:
   1. Wood stud wall:
      a. Foil faced glass fiber batts shall be stapled to the sides of the wall space leaving an air space between the foil facing and the interior sheathing.
      b. Foil faced dry wall shall be installed over furring strips on the interior stud faces. *(Note 1.8)*

F. Floor application: Radiant barrier shall be stapled to the underside of floor joists (above unheated basements or crawl spaces) to create a single reflective air space, or between the joists, followed by insulating sheathing to create two separate reflective surfaces.

3.3 FIELD QUALITY CONTROL

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved radiant barrier is used and installed as per specifications. (*Note 1.9)*

3.4 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

NOTES

SECTION 07218 – RADIANT BARRIER BUILDING INSULATION – NOTES

JUSTIFICATION

1.1 Radiant barriers lower energy consumption in a building by reducing radiant heat transfer across open spaces. Conventional insulation is only partially effective against radiant heat. The potential benefit of radiant barriers is primarily in reducing air-conditioning cooling loads in warm or hot climates. By virtue of its impermeable surface, reflective insulation also reduces convective heat transfer. The reduction of temperatures is less important in highly insulated ceiling spaces (R-30 or higher), with respect to conduction through the ceiling. If air-conditioning ductwork is located in the dropped ceiling, lowering the temperature reduces the heat gain on ductwork. Examples of radiant barrier include:

   a. Aluminum foil laminate: Aluminum foil laminated with Kraft paper, plastic film, or OSB/plywood roof sheathing.

   b. Aluminized plastic film: Thin layer of aluminum deposited on film using a vacuum process.

   c. Low-emittance coating: Liquids that reduce the emittance of the surface to which they are applied.

1.2 Radiant barriers do not use significant recycled content due to lower reflectivity of recycled aluminum. Tom Miller of Environmentally Safe Products says that aluminum with recycled content does not have the reflectivity needed for good radiant barrier performance. Choose a product that has the maximum recycled content for the specified reflectance.

1.3 Careful preparation ensures that radiant barrier can be firmly bonded with the substrate without any irregularities in the surface, which would lower the thermal performance.

1.4 Unless the shiny side has an air space next to it, the radiant barrier will not be effective.

1.5 Sealing all the joints and seams when using the radiant barrier as a vapor barrier, reduces the possibility of moisture condensation. Wherever possible, provide a mechanical seal, such as folded and stapled flaps. Most tapes will eventually fail.

1.6 Avoid compressing insulation when installing a radiant barrier because that reduces the insulation's effective R-value.

1.7 The reflective side should be protected from dust accumulation (by facing it downwards when installed in a ceiling/roof application) to ensure maximum thermal performance. Orienting the shiny side to face upwards may sometimes be unavoidable, in which case the space it is installed in shall be sealed against dust infiltration as far as possible.

1.8 Furring strips create an air space between the wall cavity and the wall insulation.

1.9 Commissioning agent shall do spot checks to ensure that the shiny side of the radiant barrier faces the specified orientation (has an air-space next to the shiny side) and is protected from dust.

NOTES

APPLICABILITY

2.1 Radiant barrier sheet applied under roof decks and above an attic or dropped ceiling.

2.2 Radiant barrier insulation applied within wall constructions and over roof deck.

2.3 Especially appropriate when ducts are located in the space under the roof deck.

2.4 Most appropriate in warm climates.

COST IMPACT

3.1 Stapled to bottom of roof rafter: $0.20 – $0.45/sq. ft.

3.2 Draped over rafters: $0.12 – $0.35/sq. ft.

3.3 Laminated to roof deck: $0.12 – $0.30/sq. ft.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Radiant barrier with 40% recycled content by Low-e Insulation. http://www.low-e.com

4.2 "Tempshield" radiant barrier with 20% recycled plastic bubble wrap by Sealed Air Corp. http://www.sealedair.com/

4.3 Astro-foil by Reflectech. http://www.videcomp.com/reflectech

4.4 “TechShield”, www.lpcorp.com

REFERENCES FOR MORE INFORMATION

5.1 http://www.rima.net/

5.2 Holmes, D.1999. Green Spec. E-Build Inc.(Product directory and guideline specifications for environmentally friendly building products).

5.3 1995. Environmental Building News. Volume 4, Number 2.

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass Fiber Batt Building Insulation

6.2 07212 Mineral Wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

6.4 07214 Glass Fiber Blown-in Building Insulation

6.5 07215 Mineral Wool Blown-in Building Insulation

6.6 07216 Cellulose Spray (Wall Cavity) Building Insulation

6.7 07217 Foam Board Building Insulation

6.8 07220 Roof and Deck Insulation.

6.9 07240 Exterior Insulating Finish System (EIFS)

6.10 07300 Shingles, Roof Tiles and Roof Coverings

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

N
O
T
E
S

6.13 07814 Cementitious Fireproofing

SECTION 07240 – EXTERIOR INSULATING FINISH SYSTEM (EIFS)

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.2 SYSTEM DESCRIPTION

A. EIFS installed in [walls] to meet specified thermal performance.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS: Submit the following in accordance with the requirements of Section 01350:
  1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
  2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07217 – Foam Board Building Insulation]

1.6 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: EIFS.

B. Performance requirements: Walls (above grade): Insulation shall have a minimum rated R-value of ____ hr. sq. ft. °F/Btu. *(Note 1.2)*

C. Substrate: [Cement Board] [High performance gypsum-fiber panels] [Standard glass-mat panels] [Paper-faced gypsum panels] [Wood-based sheathing].

D. Insulation: [Molded expanded polystyrene (EPS)] [Extruded polystyrene (XPS)] [Polyisocyanurate] [Polyurethane]
  1. Refer to Section 07217 – Foam Board Building Insulation.

E. Finish: Shall have a minimum reflectance of ___. *(Note 1.3)*

PART 3 - EXECUTION

3.1 PREPARATION *(NOTE 1.4)*

A. Substrate shall be completely dry and cured before installing the insulation board.

B. Substrate shall be free of planar irregularities greater than 1/4 in. in every 10 in. *(Note 1.5)*

C. Substrate shall be free of conditions such as moisture, dust, grease, oil, paint or foreign material that will impede adhesive bond or damage the insulation board. *(Note 1.5)*

1. Gypsum sheathing: Shall be free of warping, cracks and fins.
2. New concrete substrate: Shall have a minimum curing period of 28 days before any application.

D. Substrate shall not be installed during predominantly inclement weather conditions.

E. Gypsum sheathing with any sign of rot, dampness, dirt or damage shall be rejected and replaced.

3.2 INSTALLATION

A. Water management materials and assemblies shall be installed at terminations, interruptions (such as at control joints, expansion joints, doors and windows) or transition in the exterior substrate that are potential points for water infiltration. *(Note 1.6)*

B. Irregularities in the insulation shall be leveled and base coat shall be applied uniformly over the insulation. *(Note 1.5)*

C. Foam board application: Refer to Section 07217 – Foam Board Building Insulation.

D. Further application over the foam board surface shall not resume till the curing period as per manufacturer's specifications has been met.

E. Base coat shall be applied uniformly over the insulation board and the reinforcing mesh shall be embedded on it, with the edges overlapped by a minimum of 2 in. inches. Edges of heavy duty reinforcing meshes shall be butted and not overlapped. All corners and exposed edges shall be wrapped. No further work shall resume on this surface till it has been cured as per manufacturer's specifications.

F. Backer rods/ bond breakers and sealants shall be applied to joints between panels, expansion joints or where system abuts other materials.

3.3 FIELD QUALITY CONTROL

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved insulation material is used and installed. (*Note 1.7)*

3.4 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

SECTION 07240 – EXTERIOR INSULATING FINISH SYSTEM (EIFS) – NOTES

[See also notes for Section 07211 - Glass Fiber Batt Building Insulation and Section 07217 – Foam Board Building Insulation].

JUSTIFICATION

1.1 Exterior insulation finish systems provide thermal efficiency and weather resistance.

1.2 R-value specified here should meet or exceed the R-value specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

1.3 Consider specifying a high reflectance surface to keep the wall cooler in the sun. A reflectance of 0.70 or greater is recommended for cooling energy savings.

1.4 Proper preparation and installation ensures that EIFS is not susceptible to moisture, which reduces thermal performance.

1.5 Ensuring uniformity of EIFS surface and substrate ensures a firm bond between the two surfaces. Gaps between the substrate and insulation lower thermal performance.

1.6 Careful attention to water management is critical to avoid moisture accumulation, which can lead to mold growth and/or structural damage.

1.7 Commissioning agent shall verify that insulation and substrate is dry, clean and free of damage, and that all joints are sealed with appropriate sealant to prevent air and moisture infiltration.

APPLICABILITY

2.1 Concrete or concrete masonry walls.

2.2 Metal-framed walls, where the insulation sheathing provided as part of the EIFS will reduce thermal bridging.

COST IMPACT

3.1 Typically more expensive (per insulation R-value) than glass fiber or cellulose cavity insulation, so an EIFS is typically used for applications like those listed above where cavity insulation is not applicable or is insufficient.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 “Sparfil®” Wall System by Sparfil Blok Florida, Inc.

4.2 “R-Control” Foam-core containing 15% recycled plastic by Big Sky Insulation, Inc.

REFERENCES FOR MORE INFORMATION

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass fiber wool Batt Building Insulation

N
O
T
E
S

6.2 07212 Mineral wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

6.4 07214 Glass Fiber Blown-in Building Insulation

6.5 07215 Mineral Wool Blown-in Building Insulation

6.6 07216 Cellulose Spray (Wall Cavity) Building Insulation

6.7 07217 Foam Board Building Insulation

6.8 07218 Radiant Barrier Building Insulation

6.9 07220 Roof and Deck Insulation

6.10 07300 Shingles, Roof Tiles and Roof Coverings

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

SECTION 07300 – SHINGLES, ROOF TILES, AND ROOF COVERINGS

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

B. U-Factor: The thermal conductance of an assembly at temperature of 75 °F in units of Btu/hr. sq. ft. °F.

C. Emittance: The ratio of the radiant heat flux emitted by a specimen to that emitted by a black body at the same temperature and the same conditions.

D. Reflectance: Percentage of radiant energy reflected by a material.

1.2 SYSTEM DESCRIPTION

A. [Asphalt shingles][Clay tiles][Cedar shingles][Slate]

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS: Submit the following in accordance with the requirements of Section 01350:
   1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
   2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

PART 2 - PRODUCTS

2.1 MATERIALS

A. Performance Requirements:
   1. Roof assembly shall have a U-factor of ___ Btu/hr. sq. ft. °F. (*Note 1.4)*
   2. Product shall be ENERGY STAR compliant.
   3. Reflectance: Product shall have a minimum initial reflectance of at least __ and three-year-aged reflectance of at least __ when tested in accordance with ASTM E903. (*Note 1.5)*
   4. Emmittance: Product shall have an emittance at least 0.75 when tested in accordance with ASTM 408.

B. Asphalt shingles: *(Note 1.6)*
   1. [Organic felt] [Glass fiber mat]
   2. Recycled content for asphalt shingles: Minimum 25% recycled content. *(Note*

1.3)

3. Shall be UV resistant. *(Note 1.7)*

C. Clay tiles:

1. Shall be sourced locally. *(Note 1.8)*

D. Cedar shingles:

1. Use FSC-certified sustainably harvested wood from well-managed forests. *(Note 1.9)*

E. Slate:

1. Shall be sourced from local quarry.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prior to and during application, the contractor shall ensure that all dirt, debris, sharp edges, grease and dust shall be removed from surfaces to be roofed for both new and re-roofing substrates.

B. Substrate shall not have voids greater than 1/4 in. wide.

C. Substrate shall be dry before membrane is installed.

D. Blisters, buckles and ridges shall be cut and patched to provide a level substrate surface.

E. Contractor shall ensure that roof drain lines are unblocked before starting work.

F. Requirement and direction of vapor retarder shall be determined as per local building code.

3.2 INSTALLATION *(NOTE 1.10)*

A. Shall be installed only under environmental conditions specified by the manufacturer.

B. Only as much roofing (including flashing) as can be made weather-tight on the same day shall be installed.

C. When removing an existing roof during re-roofing, only as much roofing (including flashing) shall be removed as can be replaced and made weather-tight using roofing materials on the same day.

D. Any paint or coating applied on the membrane shall be compatible with the manufacturer's specifications.

3.3 FIELD QUALITY CONTROL

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved roof material is used and installed. (*Note 1.11)*

3.4 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

NOTES

SECTION 07300 – SHINGLES, ROOF TILES, AND ROOF COVERINGS – NOTES

JUSTIFICATION

1.1 In selecting material for roofing one should take into account its weight (heavier materials require larger support material – more intensive use of resources), its durability and thermal properties (U-factor, emittance and reflectance). Other critical factors determining the choice of the membrane are natural resources (high recycled content, recylability), quantity and toxicity of pollution generated during the manufacturing process. Products made from ecologically sensitive resources shall be avoided. Regionally manufactured products use less transportation energy. Higher recycled content ensures fewer manufacturing and landfill impacts. Low U-factor, high reflectivity and high emittance reduce cooling loads.

1.2 Roofs commonly exhibit lowest durability of any major building component except carpeting. The manufacturing process also produces a relatively high degree of pollution. Most of the roofing membranes are not bio-degradable and an environmental hazard even when they are discarded. Any measure that will increase a roof's longevity would save resources, save energy and decrease pollution.

1.3 Aside from investing in better roofing material, regional and climatic consideration can affect roof durability. Different roofing membranes have different weathering characteristics – some products stand up well to intense heat and UV radiation, but deteriorate rapidly in repeated freeze-thaw cycles. Local conditions such as hurricanes, hail etc. also effect longevity. The complete roofing assembly will be critical in determining the longevity of the membrane. Flashing details shall be designed with the longevity of the roofing material in mind, accommodating any maintenance requirements.

1.4 U-factor for the roof construction shall meet or exceed the thermal performance specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (Adopted Pursuant To Assembly Bill 970, Statutes Of 2000).

1.5 A highly reflective roof surface remains much cooler than a typical medium or dark colored roof and offers many benefits: reduced cooling energy cost, smaller air conditioning equipment, and longer roof life. The EnergyStar program lists sloped roofing products with reflectance of 0.25 or greater. However, some sloped roof products are available with much higher reflectance.

1.6 Asphalt shingles typically have an energy intensive production process. High recycled content reduces the energy used during production and also removes solid waste from landfills. Asphalt shingles can use recycled mixed paper in their base, and some use reclaimed material in the surface aggregate. Organic felt uses recycled content, where as glass fiber mats do not use any recycled content, but can last up to 60 years when installed properly. Asphalt roofing materials can be recycled into road paving or patch materials. Unless recycling options are available, asphalt shingles are best avoided.

1.7 UV resistant products have a higher durability.

1.8 Locally sourced material has lowers embodied energy as energy used for

NOTES

transportation is minimized.

1.9 Theoretically wood comes from a renewable source of energy. Sourcing wood from a well managed forest ensures that the wood that is being consumed is being restored by replantation.

1.10 Careful installation ensures that there are no potential leakages, and ensures efficient drainage that reduces moisture related damage and problems.

1.11 Commissioning agent shall ensure that the intent of the specification is met by verifying the following:

a. Check that the substrate is clean and dry before roofing material is installed.

b. Check that the roofing materials are undamaged and dry.

c. Check that the specified drainage and vent requirements are met.

APPLICABILITY

2.1 A high albedo surface may be applied to almost any roof. Cool roofs are most important in warm climates and are especially effective on roofs with little or no insulation.

2.2 See also 07610 Sheet Metal Roofing for high albedo specifications for some sloped roof applications. (e.g. to system types, construction types, occupancy types).

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 “QuiLine” roofing fabric by Bonded Fiber Products, Inc.

4.2 Organic roofing felt by Tamko Roofing Products, Inc.

4.3 Recycling by Reclaim Inc. of Tampa, Florida.

REFERENCES FOR MORE INFORMATION

5.1 EnergyStar. www.energystar.gov.

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass fiber wool Batt Building Insulation

6.2 07212 Mineral wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

6.4 07214 Glass Fiber Blown-in Building Insulation

6.5 07215 Mineral Wool Blown-in Building Insulation

6.6 07216 Cellulose Spray (Wall Cavity) Building Insulation

6.7 07217 Foam Board Building Insulation

6.8 07218 Radiant Barrier Building Insulation.

6.9 07220 Roof and Deck Insulation

REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY

6.10 07240 Exterior Insulating Finish System (EIFS)

6.11 07500 Membrane Roofing

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

SECTION 07500 – MEMBRANE ROOFING

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

B. Emittance: The ratio of the radiant heat flux emitted by a specimen to that emitted by a black body at the same temperature and the same conditions.

C. Reflectance: Percentage of radiant energy reflected by a material.

1.2 SYSTEM DESCRIPTION

A. Single ply roof membrane: [TPO] [EPDM]

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS: Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

B. Membrane rolls shall be stored flat and a few inches off the ground.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Single ply roofing system:

1. Thermoplastic Membrane: TPO (thermoplastic polyolefin)
2. Thermoset Membrane: EPDM (ethylene propylene diene monomer)

B. Performance Requirements:

1. Roof assembly shall have a U-factor of ___ Btu/hr. sq. ft. °F. (*Note 1.4)*
2. Product shall be ENERGY STAR compliant.
3. Reflectance: Product shall have a minimum initial reflectance of at least 0.65 and three-year-aged reflectance of at least 0.5 when tested in accordance with ASTM E903. (*Note 1.5)*
4. Emittance: Product shall have an emittance at least 0.75 when tested in accordance with ASTM 408.

C. Fire Retardant shall not contain chlorine or halogenated fire retardants.

PART 3 - EXECUTION

3.1 PREPARATION *(NOTE 1.6)*

A. Prior to and during application, the contractor shall ensure that all dirt, debris, sharp edges, grease and dust shall be removed from surfaces to be roofed for both new and re-roofing substrates.

B. Substrate shall not have voids greater than 1/4 in. wide.

C. Substrate shall be dry before membrane is installed.

D. Blisters, buckles and ridges shall be cut and patched to provide a level substrate surface.

E. Contractor shall ensure that roof drain lines are unblocked before starting work.

F. Requirement and direction of vapor retarder shall be determined as per local building code.

G. Insulation shall be installed as a separation layer over the existing surface and/or to obtain specified thermal value.

1. [See Section – 07217 – Foam Board Building Insulation]

3.2 INSTALLATION *(NOTE 1.7)*

A. Shall be installed only under environmental conditions specified by the manufacturer.

B. Only as much roofing (including flashing) as can be made weather-tight on the same day shall be installed.

C. When removing an existing roof during re-roofing, only as much roofing (including flashing) shall be removed as can be replaced and made weather-tight using roofing materials on the same day.

D. Membrane Installation:

1. Insulation shall be compatible with membrane as specified by manufacturer.
2. Metal flashing: Metal flashing shall be installed around the roof perimeter and roof penetrations. *(Note 1.3)*
3. Joints shall be watertight and staggered over nailer joints to prevent joints in nailers and joints in flashing from aligning. Metal edges shall not cut the membrane.
4. Adhered TPO/EPDM Roofing Membrane:
   a. Membrane shall be rolled out and laid flat. Membrane shall run perpendicular to the direction of deck flutes and the orientation of wood decks. Membrane installed around the perimeter shall be installed parallel to the perimeter edge.
   b. Sheets shall be overlapped by at least 3 in.. Sheets shall be overlapped in the direction of water-flow (like shingles) (*Note 1.7)*
   c. Creased or damaged membrane shall be replaced. Manufacturer's recommended adhesive shall be used. There shall be no air gaps, between the substrate and the membrane.
5. Mechanically Fastened TPO/EPDM Roofing Membrane:

a. Wood nailers shall be installed at the perimeter of the roof and around all penetrations and projections, and firmly anchored to the deck. Vent space shall be provided between adjacent lengths of nailers.

b. Membrane shall be installed immediately after installation of slip sheet.

c. Membrane shall be rolled out and laid flat. Membrane shall run perpendicular to the direction of deck flutes and the orientation of wood decks.

d. Sheets shall be overlapped by at least 5 in. Sheets shall be overlapped in the direction of water-flow (like shingles). *(Note 1.7)*

e. Seams shall be welded continuously.

6. Ballasted membrane system:

   a. Membrane shall be loosely laid over the insulation.

   b. Ballast shall be loosely laid over the membrane.

7. Any paint or coating applied on the membrane shall be compatible with the manufacturer's specifications.

8. Ballast: As per manufacturer's specifications.

3.3 FIELD QUALITY CONTROL

A. Commissioning agent shall be notified reasonably ahead of time to allow for inspection and verify that the approved membrane is used and installed. (*Note 1.8)*

3.4 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

N O T E S

SECTION 07500 – MEMBRANE ROOFING – NOTES

JUSTIFICATION

1.1 In selecting material for roofing one should take into account its weight (heavier materials require larger support material – more intensive use of resources), its durability and thermal properties (U-factor, emittance and reflectance).Other critical factors determining the choice of the membrane are natural resources (high recycled content, recylability), quantity and toxicity of pollution generated during the manufacturing process. Products made from ecologically sensitive resources shall be avoided. Regionally manufactured products use less transportation energy. Higher recycled content ensures fewer manufacturing impact and landfill impacts. Materials with high recycled content also have lower energy consumption during Low U-factor, high reflectivity and high emittance reduces cooling loads.

1.2 Roofs commonly exhibit lowest durability of any major building component except carpeting. The manufacturing process also produces a relatively high degree of pollution. Most of the roofing membranes are not bio-degradable and an environmental hazard even when they are discarded. Any measure that will increase a roof's longevity would save resources, save energy and decrease pollution.

1.3 Aside from investing in better roofing material, regional and climatic consideration can affect roof durability. Different roofing membranes have different weathering characteristics – some products stand up well to intense heat and UV radiation, but deteriorate rapidly in repeated freeze-thaw cycles. Local conditions such as hurricanes, hail etc. also effect longevity. The complete roofing assembly will be critical in determining the longevity of the membrane. Flashing details shall be designed with the longevity of the roofing material in mind, accommodating any maintenance requirements.

1.4 U-factor specified here shall meet or exceed the thermal performance specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (Adopted Pursuant To Assembly Bill 970, Statutes Of 2000).

1.5 A highly reflective roof surface remains much cooler than a typical medium or dark colored roof and offers many benefits: reduced cooling energy cost, smaller air conditioning equipment, and longer roof life.

1.6 Careful preparation ensures that the substrate is clean, dry and level before installing roof membrane. A clean, dry and level substrate is important in ensuring that the membrane adheres properly to the substrate and reduces frequency of replacement.

1.7 Careful installation ensures that there are no potential leakages, and ensures efficient drainage that reduces moisture related damage and problems.

1.8 Commissioning agent shall ensure that the intent of the specification is met by verifying the following:

   a. Check that the substrate is clean, level and dry before membrane is installed.

N
O
T
E
S

b. Check that membrane is undamaged and dry.

c. Check that there are no air gaps between the membrane and the substrate.

d. Verify that the membrane faces the specified orientation, the joints are staggered and overlapped as per specifications.

e. Check that the specified drainage and vent requirements are met.

APPLICABILITY

2.1 A high albedo surface may be applied to almost any roof, although it is especially easy on flat or low-slope roofs because they allow the use of white single-ply membranes or liquid-applied coatings. These coatings are most important in warm climates and are especially effective on roofs with little or no insulation.

2.2 See also 07610 Sheet Metal Roofing for high albedo specifications for some sloped roof applications. (e.g. to system types, construction types, occupancy types).

COST IMPACT

3.1 In many cases, a white, reflective membrane is available at no extra cost compared to a similar black membrane. If there is an extra cost, then it may be balanced by longer roof life and reduced replacement cost.

3.2 A white liquid-applied coating costs $0.30 to $2.00 per sq. ft to install.

3.3 Elastomeric Coatings and Single Ply membranes cost $ 1.50 to $ 3.50 per sq. ft. to install.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 “QuiLine” roofing fabric by Bonded Fiber Products, Inc.

4.2 Organic roofing felt by Tamko Roofing Products, Inc.

4.3 Recycling by Reclaim Inc. of Tampa, Florida.

REFERENCES FOR MORE INFORMATION

5.1 1995. Environmental Building News. Volume 4, Number 4. Roofing materials.

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass fiber wool Batt Building Insulation

6.2 07212 Mineral wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

6.4 07214 Glass Fiber Blown-in Building Insulation

6.5 07215 Mineral Wool Blown-in Building Insulation

6.6 07216 Cellulose Wet Spray Building Insulation

6.7 07217 Foam Board Building Insulation

6.8 07218 Radiant Barrier Building Insulation.

NOTES

6.9 07220 Roof and Deck Insulation

6.10 07240 Exterior Insulating Finish System (EIFS)

6.11 07300 Shingles, Roof Tiles, and Roof Coverings

6.12 07610 Sheet Metal Roofing

6.13 07814 Cementitious Fireproofing

SECTION 07610 – SHEET METAL ROOFING

PART 1 - GENERAL

1.1 DEFINITIONS

A. [See Section 07211 - Glass Fiber Batt Building Insulation and Section 07300 – Shingles, Roof Tiles, and Roof Coverings]

1.2 SYSTEM DESCRIPTION

A. Sheet metal roofing installed to meet the required thermal performance. (*Note 1.3)*

1.3 SUBMITTALS

A. [See Section 07211 - Glass Fiber Batt Building Insulation].

1.4 QUALITY ASSURANCE

A. [See Section 07211 - Glass Fiber Batt Building Insulation].

1.5 DELIVERY, STORAGE AND HANDLING

A. [See Section 07211 - Glass Fiber Batt Building Insulation].

1.6 WARRANTY

A. [See Section 07211 - Glass Fiber Batt Building Insulation].

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: [Aluminum] [Steel]

B. Performance Requirements:
   1. Roof Assembly shall have a U-factor of ____ Btu/hr.sq. ft. °F.(*Note 1.3)*
   2. Coating: [Zinc] [Pure Aluminum] [Galvalume (45% zinc and 55% aluminum)] [Polyester Resin]. (*Note 1.4)*
      a. Coating shall have a reflectance of over 0.65.

C. Provide products with the following recycled content – (*Note 1.6)*
   1. Provide steel roofing with at least 14% post consumer recycled content (25% total recycled content).
   2. Provide aluminum roofing with at least 75% recycled content.
   3. Provide steel tile roofing with at least 66% recycled content.
   4. Provide aluminum shake with at least 95% recycled content.
   5. Provide copper shingles with at least 85% recycled content.
   6. Fasteners:
      a. Fastening system shall be compatible with thermal expansion and contraction of the steel sheet.

2.2 SOURCE QUALITY CONTROL

A. [See Section 07211 - Glass Fiber Batt Building Insulation].

PART 3 - EXECUTION

3.1 INSTALLATION

A. Over solid deck: Z-shaped metal sleepers shall be installed over the deck. (*Note 1.7)*

3.2 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

END OF SECTION

NOTES

SECTION 07610 – SHEET METAL ROOFING – NOTES

JUSTIFICATION

1.1 In selecting material for roofing one should take into account its weight (heavier materials require larger support material – more intensive use of resources), its durability and thermal properties (U-factor, emittance and reflectance).

1.2 Other critical factors determining the choice of the membrane are natural resources (high recycled content, recylability), quantity and toxicity of pollution generated during the manufacturing process. Products made from ecologically sensitive resources shall be avoided. Regionally manufactured products use less transportation energy. Higher recycled content ensures fewer manufacturing impact and landfill impact. Low U-factor, high reflectivity and low emittance reduce cooling loads.

1.3 U-factor specified here shall meet or exceed the thermal performance specified in Table 1-H or Table 1-I of 2001 Energy Commission Efficiency Standards For Residential And Nonresidential Buildings (Adopted Pursuant To Assembly Bill 970, Statutes Of 2000).

1.4 Metal roofs have a high durability. White metal roofs have a high reflectance and in conjunction with insulation have a low-U factor. Aluminum or galvalume (zinc-aluminum alloy) coatings have a lifetime of at least 20 years and can last 40 years, as opposed to zinc coating which has a life time of only 5 years. Zinc coating can be reclaimed completely. Steel roofs are extremely durable. Silicone modified polyester finishes have a lifetime of 20 years.

1.5 Steel roofing material is made exclusively at large plants that process raw iron and is very energy intensive to manufacture. The manufacturing process also produces a relatively high degree of pollution. Metal roofing not bio-degradable.

1.6 Metal roof materials with high recycled content reduce impact on non-renewable resources and lower energy consumption during the manufacturing process. Steel and aluminum can be easily recycled in their post-use phase. Recycled aluminum uses only 15% of the energy of the virgin material.

1.7 Dark colored roof panels absorb maximum heat and experience large thermal movement (expansion and contraction due to temperature changes), increasing the fastener hole size, resulting in leaks. Panels installed over purlins will not harm the roof.

APPLICABILITY

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Rustic Shingle from Classic products, Inc.

REFERENCES FOR MORE INFORMATION

RELATED SPECIFICATION SECTIONS

6.1 07211 Glass fiber wool Batt Building Insulation

N
O
T
E
S

REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY

6.2 07212 Mineral wool Batt Building Insulation

6.3 07213 Cellulose Spray (Loose) Building Insulation

6.4 07214 Glass Fiber Blown-in Building Insulation

6.5 07215 Mineral Wool Blown-in Building Insulation

6.6 07216 Cellulose Wet Spray Building Insulation

6.7 07217 Foam Board Building Insulation

6.8 07218 Radiant Barrier Building Insulation

6.9 07220 Roof and Deck Insulation

6.10 07240 Exterior Insulating Finish System (EIFS)

6.11 07300 Shingles, Roof Tiles and Roof Coverings

6.12 07500 Membrane Roofing

6.13 07610 Sheet Metal Roofing

SECTION 07814 – CEMENTITIOUS FIREPROOFING

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.
3. Indoor air quality: Submit Material Safety Data Sheets (MSDS) and emission test data for both fireproofing and sealer. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.2 QUALITY ASSURANCE

1. Certification

1.3 DELIVERY STORAGE AND HANDLING

A. Comply with the packaging, delivery, storage and handling requirements of section 01350.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 CLEANING

A. [See Section 07211 - Glass Fiber Batt Building Insulation]

B. Remove overspray from adjacent surfaces.

END OF SECTION

CONTENTS

CONTENTS 1
DISCLAIMER 2
SECTION 08100 – METAL DOORS AND FRAMES 3
SECTION 08100 – METAL DOORS AND FRAMES – NOTES 6
SECTION 08200 – WOOD DOORS 8
SECTION 08200 – WOOD DOORS – NOTES 11
SECTION 08331 – OVERHEAD COILING DOORS 13
SECTION 08331 – OVERHEAD COILING DOORS – NOTES 15
SECTION 08410 – METAL-FRAMED STOREFRONTS 17
SECTION 08410 – METAL-FRAMED STOREFRONTS – NOTES 20
SECTION 08520 – ALUMINUM WINDOWS 22
SECTION 08520 – ALUMINUM WINDOWS – NOTES 25
SECTION 08550 – WOOD-FRAMED WINDOWS 27
SECTION 08550 – WOOD-FRAMED WINDOWS – NOTES 30
SECTION 08620 – UNIT SKYLIGHTS 33
SECTION 08620 – UNIT SKYLIGHTS – NOTES 36
SECTION 08630 – METAL-FRAMED SKYLIGHTS 38
SECTION 08630 – METAL-FRAMED SKYLIGHTS - NOTES 41
SECTION 08810 – GLASS 43
SECTION 08810 – GLASS – NOTES 45
SECTION 08910 – METAL-FRAMED CURTAIN WALL 48
SECTION 08910 – METAL-FRAMED CURTAIN WALL – NOTES 51

DISCLAIMER

SECTION 08100 – METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. °F.

1.2 SYSTEM DESCRIPTION

A. [Aluminum] [Steel] [Glazing panel] doors installed to maintain specified thermal performance.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: [Insulated] metal doors.

B. Performance Requirements:

1. All opaque doors, including swinging doors and non-swinging doors shall have the following thermal performance criteria. (*Note 1.1).*
    a. U-factor for metal non-swinging doors shall not be greater than 1.45 (Btu/hr. sq. ft. °F)
    b. U-factor for metal swinging doors, including fire-rated doors, insulated access hatches, and insulated smoke vents shall not be greater than 0.50 (Btu/hr. sq. ft. °F).
2. Swinging doors shall have an insulated core. *(Note 1.2)*

C. Recycled Content: *(Note 1.3)*
   1. Aluminum doors: Minimum 75% post-consumer recycled content.
   2. Steel doors: Minimum 17% post-consumer recycled content, 35% total recycled content.

D. Door: [Steel] [Aluminum]
   1. All joints shall be continuously welded to create a smooth unbroken surface. *(Note 1.4)*
   2. All points of contact between the operable and non-operable components of the door shall be weatherstripped. If weatherstripping is not used, the edge shall be welded using laser technology. *(Note 1.5)*
   3. Door frame shall have continuous thermal break between the interior and exterior surfaces. *(Note 1.6)*
   4. Thermally broken sections shall not be assembled by means of screws or other fasteners. *(Note 1.7)*
   5. Where thermally broken welded frame product is specified, welds shall not cause thermal transfers between exterior and interior surfaces. *(Note 1.7)*

E. Finish and primer:
   1. Refer to Section 01350 – Special Environmental Requirements.
   2. Refer to Section 9910 – Paints.

F. Recyclability: Project goal is to provide products that are installed and maintained to ensure reusability.

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:
   1. Doors shall be shop primed and finished. *(Note 1.8)*
   2. For touch-up in field refer to Section 01350 – Special Environmental Requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Product shall be examined for damage, signs of warping, denting or splitting and replaced immediately. Products with signs of any damage, mildew, and other contamination shall be rejected. *(Note 1.9)*

B. Gaskets with gaps or other visible installation irregularities on door units that are delivered to site shall be corrected by manufacturer. *(Note 1.9)*

C. Examine door frame opening before product is installed to verify that they are installed plumb, true and level. *(Note 1.10)*

D. Wall space around the frame shall be filled with batt insulation. *(Note 1.11)*

3.2 INSTALLATION

A. Frame product shall be set plumb, square, aligned and without twist at correct elevation. Product shall be tightly fitted to the opening, rigidly secured in place and properly braced. *(Note 1.10)*

B. [Vinyl] nailing fins shall be used on clad doors, and on frame exterior to form a weather tight perimeter. *(Note 1.5)*

C. Door seal members shall be set in a bed of sealant to provide weather tight conditions. *(Note 1.5)*

3.3 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the site waste management program, section 01565.

END OF SECTION

NOTES

SECTION 08100 – METAL DOORS AND FRAMES – NOTES

JUSTIFICATION

1.1 Doors specified in this section ensure that the thermal performance specified in ASHRAE standard 90.1 - 2001 are met. Doors with low thermal transmittance (u-factor) lower energy consumption in a building.

All opaque doors with U-factors determined, certified, and labeled in accordance with NFRC 100 as specified in 5.2.2 shall be assigned those U-factors. Unlabeled opaque doors shall be assigned the following U-factors:

a. Uninsulated single-layer metal swinging doors or non-swinging doors, including single-layer uninsulated access hatches and uninsulated smoke vents: 1.45.
b. Uninsulated double-layer metal swinging doors or non-swinging doors, including double-layer uninsulated access hatches and uninsulated smoke vents: 0.70.
c. Insulated metal swinging doors, including fire-rated doors, insulated access hatches, and insulated smoke vents: 0.50.
d. No credit shall be given for any other features, including thermal breaks in metal door slabs (the operable part of the door) or frames, other than as determined in accordance with 5.2.2.

1.2 Metal doors would typically have higher thermal transmittance than wood. Metal doors with insulated cores have better energy performance than many wood doors, resulting in long-term energy benefits.

1.3 Manufacturing process for metal products is energy intensive. Recycled content saves resources and lowers energy consumed during production. Sheet steel from Nucor has up to 75% post-consumer recycled content.

1.4 Having an unbroken seam is critical in eliminating air/moisture penetration into the insulating core. A smooth precise edge ensures a tight fit between the door panel and the frame, minimizing energy loss through air infiltration between the outside and the inside when the door is closed.

1.5 Reducing air infiltration reduces heating and cooling energy. Weather stripping or using sealants ensures a weather tight system. The laser weld does not use filler material and is more uniform. It also ensures the most precise edge in the market. Both these factors ensure that there is minimal energy loss through infiltration. The laser edge does not use any grinding and stays stronger for a longer period of time, which maximizes the usability of the product.

1.6 Metal frames have high conductance. Thermal breaks reduce energy consumption by reducing thermal conduction between the interior and exterior surfaces.

1.7 Fastening screws or using other conductive fasteners form thermal bridges and increase thermal conduction between the indoor and outdoor.

1.8 Field painting is not desirable due to indoor air quality issues.

1.9 Any irregularity or damage to the edges will prevent a tight fit, and increase infiltration. Moisture penetration into the insulation core will reduce thermal performance of the assembly. Both these factors will contribute to increase in heating and cooling energy.

1.10 If the openings or frame are not plumb and level, or the corners do not meet at right angles, the product and the opening will not fit tightly, making it susceptible to energy loss through air infiltration

1.11 Filling the wall space around the frame with insulation ensures thermal integrity of the walls and door.

APPLICABILITY

2.1 Metal doors installed in commercial buildings.

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Steel doors and frames by Amweld Building Products, Inc. http://www.amweld.com/

4.2 Steel doors and frames by S. W. Fleming Limited. http://www.flemingdoor.com/

4.3 Insulated steel doors by Loewen Windows

4.4 Insulated steel doors by Castlegate , Inc.

4.5 Insulated steel doors by Ducana Windows & Doors Ltd. http://www.ducana.com/

4.6 Insulated steel doors by Ambico Ltd. http://www.doors-ambico.com/

REFERENCES FOR MORE INFORMATION

5.1 ASHRAE/IESNA. 2001. Standard 90.1 – 2001. ASHRAE. (Recommended U-factors for door assemblies).

5.6 Malin, Nadav. 1994. Environmental Building News. Vol. 3. Number 4. pp. 14-17. (Recycled content).

5.7 http://www.afsonl.com/products. (Building product information).

RELATED SPECIFICATION SECTIONS

6.1 08810 Glass (Use only if door has a glass panel)

6.2 08200 Wood and Plastic doors

6.3 08331 Overhead Coiling doors

SECTION 08200 – WOOD DOORS

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft °F.

1.2 SYSTEM DESCRIPTION

A. Provide [wood] [MDF] doors installed to maintain the specified thermal performance.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, Forest-Stewardship Council-certified sustainable harvested wood products, and product recyclability. Resource efficient product data:
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. For doors where the finish material is installed over a substrate, either with or without the use of adhesives, individual components shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer’s recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer’s recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.4 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Keep certified wood products separate from non-certified wood products, for auditing purposes (as mandated by the certifier).

B. Keep wood products dry.

C. Refer to Section 01350 – Special Environmental Requirements.

D. Refer to Section 01565 – Site Waste Management Program.

1.6 SITE CONDITIONS

A. Keep wood products dry.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Opaque [wood] [composite] doors.

B. Performance Requirements:
   1. All opaque doors, including swinging doors and non-swinging doors shall have the following thermal performance criteria. (*Note 1.1).*
      a. U-factor for non-swinging doors shall not be greater than 1.45 (Btu/hr. sq. ft. °F)
      b. U-factor for wood swinging doors, including fire-rated doors, insulated access hatches, and insulated smoke vents shall not be greater than 0.50 (Btu/hr. sq. ft. °F).

C. Indoor Air Quality Criteria:
   1. Use products with low-VOC sealers and adhesives. *(Note 1.3)*
   2. Only low odor/low-VOC-emitting core boards, composite wood products, and MDF shall be used on the project. No exposed particleboard will be allowed. *(Note 1.3)*

D. Recycled Content: *(Note 1.4)*
   1. MDF doors: Minimum 94% total recycled content, at least 10% of which shall be post-consumer recycled content.

E. All points of contact between the operable and non-operable components of the door shall be weatherstripped. *(Note 1.5)*

F. Wood Door and Frame
   1. Use FSC-certified sustainably harvested woods from well-managed forests. *(Note 1.6)*
   2. Shall not contain particleboard.
   3. Use core board, composite wood products, and MDF.

G. MDF Door
   1. Provide FSC-certified MDF where possible. *(Note 1.6)*

H. Frame: [Wood]
   1. Cladding [Optional]: Frames with aluminum cladding shall be of premium grade tempered aluminum.
      a. Cladding shall be mitered at the head corners
      b. Cladding shall be durable and weather-tight.
      c. Aluminum shall be [anodized] or have [polyvinylidene flouride] [siliconized polyester] finish.

I. Finish: [Specify] [Paint] [Fiberglass Face Sheet] [Wood veneer]:
   1. Paint and primer:
      a. Refer to Section 01350 – Special Environmental Requirements.

b. Refer to Section 9910 – Paints.

2. Wood veneer:

a. Use FSC-certified sustainably harvested wood from well-managed forests. *(Note 1.6)*

b. Veneer shall be manufactured in a facility approved by an agency accredited by the Forest Stewardship Council.

J. Recyclability:

1. Project goal is to provide products that are installed and maintained to ensure reusability.

2. MDF shall be recyclable.

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:

1. Doors shall be shop primed and finished. *(Note 1.7)*

2. For touch-up in field refer to Section 01350 – Special Environmental Requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Product shall be examined for damage, signs of warping, denting or splitting and replaced immediately. Products with signs of any damage, mildew, and other contamination before installation shall be rejected. *(Note 1.8)*

B. Gaskets with gaps or other visible installation irregularities on door units that are delivered to site shall be corrected by manufacturer. *(Note 1.8)*

C. Examine all door frames opening before product is installed to verify that they are installed plumb, true and level. *(Note 1.9)*

D. Wall space around the frame shall be filled with pieces of batt insulation. *(Note 1.10)*

3.2 INSTALLATION

A. Frame product shall be set plumb, square, aligned and without twist at correct elevation. Product shall be tightly fitted to the opening, rigidly secured in place and properly braced. *(Note 1.9)*

B. [Vinyl] nailing fins shall be used on clad doors, and on frame exterior to form a weather tight perimeter*. (Note 1.5)*

C. Door seal members shall be set in a bed of sealant to provide weather tight conditions. *(Note 1.5)*

3.3 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 08200 – WOOD DOORS – NOTES

JUSTIFICATION

1.1 Doors specified in this section ensure that the thermal performance specified in ASHRAE standard 90.1 - 2001 are met. Doors with low thermal transmittance (U-factor) lower energy consumption in a building.

All *opaque doors* with *U-factors* determined, certified, and labeled in accordance with NFRC 100 as specified in 5.2.2 shall be assigned those *U-factors*. *Unlabeled opaque doors* shall be assigned the following *U-factors*:

a. Wood *doors*, minimum nominal thickness of 1 3/4 in., including panel *doors* with minimum panel thickness of 1 1/8 in., solid core flush *doors*, and hollow core flush *doors*: 0.50.

b. Any other wood *door*: 0.60.

c. No credit shall be given for any other features, including thermal breaks in metal door slabs (the operable part of the door) or frames, other than as determined in accordance with 5.2.2.

1.2 Wood doors have lower thermal transmittance than metal doors and would typically consume less energy than uninsulated metal doors.

1.3 Low VOC products have a lower impact on indoor air quality.

1.4 Recycled content saves resources and lowers energy consumed during production.

1.5 Reducing air infiltration reduces heating and cooling energy. Weatherstripping or using sealants ensures a weather tight system.

1.6 Wooden doors theoretically use a renewable source when they are sourced from a well-managed forest and have low embodied energy. Wood products that are not sourced from well-managed forests have a huge environmental impact. Assemblies made from salvaged wood also conserve resources.

1.7 Field painting is not desirable due to indoor air quality issues.

1.8 Any irregularity or damage to the edges will prevent a tight fit, and increase infiltration. This will contribute to increase in heating and cooling energy.

1.9 If the openings or frame are not plumb and level, or the corners do not meet at right angles, the product and the opening will not fit tightly, making it susceptible to energy loss through air infiltration.

1.10 Filling the wall space around the frame with insulation ensures thermal integrity of the walls and door.

APPLICABILITY

2.1 Exterior and interior application of wood doors in commercial buildings.

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Energy Efficient Doors by Andersen Windows, Inc.

http://commercial.andersenwindows.com

4.2 Caridon Peachtree Doors and Windows, Inc.

4.3 "Elite Exterior" by Jeld-Wen. http://www.JELD-WEN.com/

4.4 Resource efficient glazed wood doors by Norco Window Company. http://www.norcomfg.com/

4.5 Ecocolors (Agriculture fiber waste board) by Architectural Forest Enterprises Inc. http://www.ecoforest.com

4.6 Reuse and total recycling systems by Urban Ore, Inc. Berkeley, CA

4.7 "Renewal" program for retrofitting existing buildings and reusing old materials by Andersen Windows, Inc. http://www.renewalbyandersen.com/flash/index.html

REFERENCES FOR MORE INFORMATION

5.1 http://www.afsonl.com/products. (Building product information).

RELATED SPECIFICATION SECTIONS

6.1 06070 – Wood Treatment

6.2 06080 – Factory Applied wood coating

6.3 08100 – Metal doors and Frames

6.4 08810 – Glass

SECTION 08331 – OVERHEAD COILING DOORS

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Provide [steel] [aluminum] overhead coiling doors and frame, which have installed to maintain the specified thermal performance. *(Note 1.1)*

1.2 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.3 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.4 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: [Insulated] overhead doors.

1. U-factor shall not be greater than 1.45 (Btu/hr. sq. ft. °F). *(Note 1.1)*

B. Doors shall have an insulated core. (*Note 1.2)*

C. Recycled Content: *(Note 1.3)*

1. Aluminum doors: Minimum 75% post-consumer recycled content.
2. Steel doors: Minimum 17% post-consumer recycled content, 35% total recycled content.

D. Door: [Steel] [Aluminum]

1. The perimeter shall have a continuous weather strip. *(Note 1.4)*
2. Metal doors shall have continuous thermal break between the interior and exterior surfaces. *(Note 1.5)*
3. Thermally broken sections shall not be assembled by means of screws or other fasteners. *(Note 1.6)*

E. Finish and primer:

1. Refer to Section 01350 – Special Environmental Requirements.

2. Refer to Section 9910 – Paints.

F. Recyclability: Project goal is to provide products that are installed and maintained to ensure reusability.

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:
  1. Doors shall be shop primed and finished. *(Note 1.7)*
  2. For touch-up in field refer to Section 01350 – Special Environmental Requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Product shall be examined for damage, signs of warping, denting or splitting and replaced immediately. Products with signs of any damage, mildew, and other contamination shall be rejected. *(Note 1.8)*

B. Gaskets with gaps or other visible installation irregularities on door units that are delivered to site shall be corrected by manufacturer. *(Note 1.8)*

C. Examine all door frames opening before product is installed to verify that they are installed plumb, true and level. *(Note 1.9)*.

D. Wall space around the frame shall be filled with batt insulation. *(Note 1.10)*.

3.2 INSTALLATION

A. Product shall be tightly fitted to the opening, rigidly secured in place and properly braced. *(Note 1.9)*.

B. Door seal members shall be set in a bed of sealant to provide weather tight conditions. *(Note 1.4)*.

3.3 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 08331 – OVERHEAD COILING DOORS – NOTES

JUSTIFICATION

1.1 Doors specified in this section ensure that the thermal performance specified in ASHRAE standard 90.1 - 2001 are met. Doors with low thermal transmittance (u-factor) lower energy consumption in a building.

All *opaque doors* with *U-factors* determined, certified, and labeled in accordance with NFRC 100 as specified in 5.2.2 shall be assigned those *U-factors*. *Unlabeled opaque doors* shall be assigned the following *U-factors*:

a. Uninsulated single-layer metal *non-swinging doors*: 1.45
b. Uninsulated double-layer metal *non-swinging doors*: 0.70
c. No credit shall be given for any other features, including thermal breaks in metal door slabs (the operable part of the door) or frames, other than as determined in accordance with 5.2.2.

1.2 Metal doors typically have higher thermal transmittance than wood. Metal doors with insulated cores have better energy performance than many wood doors, resulting in long-term energy benefits.

1.3 Manufacturing process for metal products is energy intensive. Recycled content saves resources, lowers energy consumed during production.

1.4 Reducing air infiltration reduces heating and cooling energy. Weather stripping or using sealants ensures a weather tight system.

1.5 Metal frames have high thermal conductivity. Thermal breaks reduce energy consumption by reducing thermal conductance between the interior and exterior surfaces.

1.6 Fastening screws or using other conductive fasteners form thermal bridges and increase thermal exchange between the indoor and outdoor.

1.7 Field painting is not desirable due to indoor air quality related issues.

1.8 Any irregularity or damage to the edges will prevent a tight fit, and increase infiltration. Moisture penetration into the insulation core will reduce thermal performance of the assembly. Both these factors will contribute to increase in heating and cooling energy.

1.9 Checking that the door frame opening is set plumb and the frame is installed plumb and level will ensure a tight fit and reduce air infiltration.

1.10 Filling the wall space around the frame with insulation ensures thermal integrity of the walls and door.

APPLICABILITY

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Insulated Overhead Steel doors by Overhead Doors. http://www.overheaddoor.com/

N
O
T
E
S

4.2 Thermacore Insulated doors by Overhead Doors. http://www.overheaddoor.com/

4.3 Insulated Overhead doors by Armalite. http://www.armrlite.com/

REFERENCES FOR MORE INFORMATION

RELATED SPECIFICATION SECTIONS

SECTION 08410 – METAL-FRAMED STOREFRONTS

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. °F.

B. SHGC (Solar Heat Gain Coefficient): The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

C. Visible Light Transmittance (T_{VIS}): Percentage of incident light energy transmitted by glazing.

1.2 SYSTEM DESCRIPTION

A. Metal-framed storefront assembly installed to maintain specified thermal performance.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Metal-framed storefront wall with [insulated] glass. *(Note 1.2)*

B. Performance criteria:

1. Metal framed storefront assembly (including glass and frame): U-factor shall be rated, certified and labeled in accordance with NFRC 100.

a. U-factor of storefront assembly shall not be greater than ____(Btu/hr. sq. ft. °F). *(Note 1.3)*

2. Metal framed storefront assembly (including glass, sash and frame): SHGC shall be rated, certified and labeled in accordance with NFRC 200.

   a. Storefront assembly shall have a solar heat gain coefficient equal to or less than ____. *(Note 1.4)*

3. Glass: Visible light transmittance shall be rated, certified and labeled in accordance with NFRC 300.

   a. Visible light transmittance shall not be less than ____. *(Note 1.5)*

4. Metal framed storefront assembly (including glass, sash and frame): Air leakage shall be rated, certified and labeled in accordance with NFRC 400, and shall not exceed 0.4 cfm/sq. ft. *(Note 1.6)*

C. Recycled Content: *(Note 1.7)*

1. Aluminum frame: Minimum 75% post-consumer recycled content.
2. Steel frame: Minimum 17% post-consumer recycled content, 35% total recycled content.

D. Mullions: Shall be thermally broken. *(Note 1.8)*

E. Frame: [Steel] [Aluminum]

1. All points of contact between the operable and non-operable components of the curtain wall shall be weatherstripped. If weatherstripping is not used, the edge shall be welded using laser technology. *(Note 1.6)*
2. Storefront frame shall have continuous thermal break between the interior and exterior surfaces. *(Note 1.8)*
3. Thermally broken sections shall not be assembled by means of screws, gammets or other fasteners. *(Note 1.9)*
4. Where thermally broken welded frame product is specified, welds shall not cause thermal transfers between exterior and interior surfaces. *(Note 1.9)*

F. Glazing Panel: [Insulated] [Monolithic] glass *(Note 1.2)*

1. Glass type: [Clear] [Tinted] [high performance tint] [Low-e coating]. Refer Section 8810 – Glass. *(Note 1.5)*
2. Color of tint: [Specify only if applicable] Refer Section 8810 – Glass
3. Center of Glass U-factor: Refer Section 8810 – Glass.
4. Solar Heat Gain Coefficient: Refer Section 8810 – Glass.
5. Visible Transmittance: Refer Section 8810 – Glass
6. Glazing panel shall have a double weather seal.

G. Finish and primer:

1. Refer to Section 01350 – Special Environmental Requirements.
2. Refer to Section 9910 – Paints.

H. Storefront system shall have adequate drainage channels to drain the water entering the joints and condensation occurring within the system through drain holes and gutters of adequate size to the exterior surface of the wall. There shall be no moisture or air penetration through the storefront.

I. Recyclability: Project goal is to provide products that are 100 percent recyclable or reusable.

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:
   1. Store front shall be shop-primed and painted. *(Note 1.10)*
   2. For touch-up in field refer to Section 01350- Special Environmental Requirement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Metal storefront components shall be examined for damage, signs of warping, denting or splitting and replaced immediately. Products with signs of any damage, mildew, and other contamination before installation shall be rejected. *(Note 1.11)*

B. Gaskets with gaps or other visible installation irregularities on framing delivered to site shall be corrected by manufacturer. *(Note 1.11)*

C. Examine all wall openings before product is installed to verify that they are installed plumb, true and level. *(Note 1.13)*

D. Wall space around the frame shall be filled with batt insulation. *(Note 1.13)*

3.2 INSTALLATION

A. Frame product shall be set plumb, square, aligned and without twist at correct elevation. Product shall be tightly fitted to the opening, rigidly secured in place and properly braced. *(Note 1.12)*

B. Sill members shall be set with joint fillers or gaskets to provide weather tight construction. *(Note 1.5)*

3.3 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 08410 – METAL-FRAMED STOREFRONTS – NOTES

JUSTIFICATION

1.1 Windows are a source of daylighting, and can reduce lighting loads in a commercial application. Daylighting has also been associated with health and productivity benefits.

1.2 Insulated (dual-pane) glazing has lower thermal conductance than monolithic glass.

1.3 Metal framed storefronts typically have very high conductivity and can increase energy consumption in a building. Storefronts with low thermal conductance (U-factor) reduce energy consumption in a building. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method. Most climate zones in California require double-glazed windows. Insulated glass and thermal breaks reduce thermal transmission from the exterior to the interior.

1.4 A lower SHGC contributes to energy efficiency in a cooling dominated climate and a higher SHGC is beneficial in a heating dominated climate. A low SHGC is recommended for California climates. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method.

1.5 High visible transmittance is preferred for daylighting purposes. Typically, high visible light transmittance is associated with a higher SHGC, which is not desirable in most California climate zones. Select glazing that has a high visible light transmittance and low SHGC for most California climate zones. High performance glazing has a low SHGC and high visible light transmittance, which is ideal for daylighting and cooling benefits. High performance glass lowers radiant heat transfer from the exterior to the interior, without greatly compromising the visible light transmittance.

1.6 Reducing air infiltration reduces heating and cooling energy. Weather stripping or using sealants ensures a weather tight system.

1.7 Manufacturing process for metal products is energy intensive. Recycled content saves resources and lowers energy consumed during production.

1.8 Thermal breaks reduce energy transfer between the interior surface and the exterior.

1.9 Fastening screws or using other conductive fasteners form thermal bridges and increase thermal conduction between the indoor and outdoor.

1.10 Field painting is not desirable due to indoor air quality issues.

1.11 Any irregularity or damage to the edges will prevent a tight fit, and increase

N O T E S

infiltration. This will contribute to an increase in heating and cooling energy.

1.12 If the openings or frame are not plumb and level, or the corners do not meet at right angles, the product and the opening will not fit tightly, making it susceptible to energy loss through air infiltration.

1.13 Filling the wall space around the frame with insulation ensures thermal integrity of the walls and the storefront.

APPLICABILITY

2.1 Metal framed storefront walls installed in commercial buildings.

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Thermally broken aluminum Entrances & Storefronts by Arch Aluminum & Glass Co., Inc. http://www.arch.amarlite.com

4.2 Series 403 (thermally broken) Aluminum Storefront by EFCO® Corporation. http://www.efcocorp.com

4.3 Thermally broken aluminum Entrances & Storefronts by The Baut Studios, Inc. http://www.baut.com

4.4 Thermolite® Insulated Composite Glazing Panel by Laminators, Inc. http://www.omegapanels.com

4.5 The 14000 Series Framing System by Tubelite® Inc. http://www.tubelite.com

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

RELATED SPECIFICATION SECTIONS

6.1 08520 - Aluminum-framed storefronts

6.2 08550 – Wood framed Windows

6.3 08560 - Plastic-framed Windows

6.4 08565 - Glass-Fiber-Framed Windows

6.4 08620 - Unit Skylights

6.6 08630 - Metal-framed skylights

6.7 08810 – Glass

SECTION 08520 – ALUMINUM WINDOWS

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. °F.

B. SHGC (Solar Heat Gain Coefficient): The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

C. Visible Light Transmittance (T_{VIS}): Percentage of incident light energy transmitted by glazing.

1.2 SYSTEM DESCRIPTION

A. Aluminum frame window installed to maintain specified thermal performance.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Aluminum framed windows.

B. Performance Requirements:

1. Aluminum framed window assembly (including glass, sash and frame) U-factor shall be rated, certified and labeled in accordance with NFRC 100.
   a. U-factor of window assembly shall not be greater than ____(Btu/hr. sq. ft. °F).

(Note 1.2)

2. Aluminum framed window assembly (including glass, sash and frame) SHGC shall be rated, certified and labeled in accordance with NFRC 200.
   a. SHGC of window assembly shall not be greater than ____. *(Note 1.3)*
3. Glass: Visible light transmittance shall be rated, certified and labeled in accordance with NFRC 300.
   a. Visible light transmittance shall not be less than ____. *(Note 1.4)*
4. Aluminum framed window assembly (including glass, sash and frame): Air leakage shall be rated, certified and labeled in accordance with NFRC 400, and shall not exceed 0.4 cfm/sq. ft. *(Note 1.5)*

C. Recycled content: *(Note 1.6)*
   1. Aluminum frames: Minimum 75% post-consumer recycled content.

D. Mullions: Shall be thermally broken. *(Note 1.7)*

E. Frame: [Aluminum]
   1. All points of contact between the operable and non-operable components of the door shall be weatherstripped. If weatherstripping is not used, the edge shall be welded using laser technology. *(Note 1.5)*
   2. A continuous thermal break shall be present between any two metal [or any other highly conductive material] surfaces, when one faces the external environment and the other faces the interior. *(Note 1.7)*
   3. Thermally broken sections shall not be assembled by means of screws, gammets or other fasteners. *(Note 1.8)*
   4. Where thermally broken welded frame product is specified, welds shall not cause thermal transfers between exterior and interior surfaces. *(Note 1.8)*

F. Glazing Panel: [Insulated] [Monolithic] glass *(Note 1.9)*
   1. Glass type: [Clear] [Tinted] [high performance tint] [Low-e coating]. Refer Section 8810 – Glass. *(Note 1.4)*
   2. Color of tint: [Specify only if applicable] Refer Section 8810 – Glass
   3. Center of Glass U-factor: Refer Section 8810 – Glass.
   4. Solar Heat Gain Coefficient: Refer Section 8810 – Glass.
   5. Visible Transmittance: Refer Section 8810 – Glass
   6. Glazing panel shall have a double weather seal.

G. Finish and primer:
   1. Refer to Section 01350 – Special Environmental Requirements.
   2. Refer to Section 9910 – Paints.

H. Recyclability: Project goal is to provide products that are 100 percent recyclable or reusable.

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:
   1. Window shall be shop-primed and painted. *(Note 1.10)*
   2. For touch-up in field refer to Section 01350- Special Environmental Requirement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Aluminum framed window components shall be examined for damage, signs of warping, denting or splitting and replaced immediately. Products with signs of any damage, mildew, and other contamination before installation shall be rejected. *(Note 1.11)*

B. Gaskets with gaps or other visible installation irregularities on framing delivered to site shall be corrected by manufacturer. *(Note 1.11)*

C. Examine all wall openings before product is installed to verify that they are installed plumb, true and level. *(Note 1.12)*

D. Wall space around the frame shall be filled with insulation. *(Note 1.13)*

3.2 INSTALLATION

A. Frame product shall be set plumb, square, aligned and without twist at correct elevation. Product shall be tightly fitted to the opening, rigidly secured in place and properly braced. *(Note 1.12)*

B. [Vinyl] nailing fins shall be used on frame exterior to form a weather tight perimeter. *(Note 1.5)*

C. Sill members shall be set with joint fillers or gaskets to provide weather tight construction. *(Note 1.5)*

3.3 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

N O T E S

SECTION 08520 – ALUMINUM WINDOWS – NOTES

JUSTIFICATION

1.1 Windows are a source of daylighting, and can reduce lighting loads in a commercial application. Daylighting has also been associated with health and productivity benefits.

1.2 Aluminum framed windows typically have very high thermal conductivity and can increase energy consumption in a building. Windows with low thermal transmittance (U-factor) reduce energy consumption in a building. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method. Most climate zones in California require double-glazed windows. Insulated glass and thermal breaks lower thermal transmission from the exterior to the interior.

1.3 A lower SHGC contributes to energy efficiency in a cooling dominated climate and a higher SHGC for a heating dominated climate. A low SHGC is recommended for California climates. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method.

1.4 High visible transmittance is preferred for daylighting purposes. Typically, high visible light transmittance is associated with a higher SHGC, which is not desirable in most California climate zones. Select glazing that has a high visible light transmittance and low SHGC for most California climate zones. High performance glazing has a low SHGC and high visible light transmittance, which is ideal for daylighting and cooling benefits. High performance glass lowers radiant heat transfer from the exterior to the interior, without greatly compromising the visible light transmittance.

1.5 Reducing air infiltration reduces heating and cooling energy. Weatherstripping or using sealants ensures a weather tight system.

1.6 Manufacturing process for metal products is energy intensive. Recycled content in each of the components saves resources, lowers energy consumed during the manufacturing process.

1.7 Metal frames have a high thermal conductance. Thermal breaks reduce energy loss from the interior surface to the exterior.

1.8 Fastening screws or using other conductive fasteners form thermal bridges and increase thermal conduction between the indoor and outdoor.

1.9 Insulated glass has lower thermal conductance than monolithis glass.

1.10 Field painting is not desirable due to indoor air quality issues.

1.11 Any irregularity or damage to the edges will prevent a tight fit, and increase

NOTES

infiltration. This will contribute to increase in heating and cooling energy.

1.12 If the openings or frame are not plumb and level, or the corners do not meet at right angles, the product and the opening will not fit tightly, making it susceptible to energy loss through air infiltration.

1.13 Filling the wall space around the frame with insulation ensures thermal integrity of the walls and the storefront.

APPLICABILITY

2.1 Aluminum framed windows installed in commercial buildings.

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Starline commercial windows by Starline Industries. http://www.starlineindustries.com

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

RELATED SPECIFICATION SECTIONS

6.1 08410 – Metal-framed storefronts

6.2 08550 – Wood framed Windows

6.3 08560 – Plastic-framed Windows

6.4 08565 – Glass-Fiber-Framed Windows

6.4 08620 – Unit Skylights

6.6 08630 – Metal-framed skylights

6.7 08810 – Glass

SECTION 08550 – WOOD-FRAMED WINDOWS

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. °F.

B. SHGC (Solar Heat Gain Coefficient): The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

1.2 SYSTEM DESCRIPTION

A. Wood frame windows, which have been installed to maintain specified thermal criteria.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

[Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.]

1.4 DELIVERY, STORAGE AND HANDLING

A. Keep certified wood products separate from non-certified wood products, for auditing proposes (as mandated by the certifier).

B. Keep wood products dry.

C. Refer to Section 01350 – Special Environmental Requirements.

D. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: [____-clad] [Wood] framed windows.

B. Performance Requirements:

1. Wood framed window assembly (including glass, sash and frame) U-factor shall be rated, certified and labeled in accordance with NFRC 100.
   a. U-factor of window assembly shall have a not be greater than ____(Btu/hr. sq. ft. °F). *(Note 1.2)*
2. Wood framed window assembly (including glass, sash and frame) SHGC shall be

rated, certified and labeled in accordance with NFRC 200.

a. Solar Heat Gain Coefficient (SHGC) of window assembly shall not be greater than ____.*(Note 1.3)*

3. Glass: Visible light transmittance shall be rated, certified and labeled in accordance with NFRC 300.

a. Visible light transmittance shall not be less than ____. *(Note 1.4)*

4. Wood framed window assembly (including glass, sash and frame): Air leakage shall be rated, certified and labeled in accordance with NFRC 400, and shall not exceed 0.4 cfm/sq. ft. *(Note 1.5)*

C. Frame

1. Wood :

a. Use FSC-certified sustainably harvested wood from well-managed forests. *(Note 1.6)*

D. Glazing Panel: [Insulated] [Monolithic] glass *(Note 1.7)*

1. Glass type: [Clear] [Tinted] [High performance tint] [low-e coating] Refer Section 8810 – Glass. *(Note 1.4)*
2. Color of tint: [Specify only if applicable] Refer Section 8810 – Glass.
3. Center of Glass U-factor: Refer Section 8810 – Glass.
4. Solar Heat Gain Coefficient: Refer Section 8810 – Glass.
5. Visible Transmittance: Refer Section 8810 – Glass.
6. Glazing panel shall have a double weather seal.

E. All points of contact between the operable and non-operable components of the the window shall be weatherstripped. *(Note 1.5)*

1. Casement and Awning: Shall consist of two piece weatherstrip system consisting of a frame mounted, compression bulb and a secondary compression bulb on three sides of the operating sash.
2. Double-hung windows: Shall consist of a two piece weather-stripping system, including a frame mounted rigid jamb liner and compression type weather strip on the sill and head.

F. Cladding/Finishes: [Specify] [Paint] [Wood veneer]:

1. Wood veneer:

a. Use FSC-certified sustainably harvested wood from well-managed forests. *(Note 1.6)*

b. Veneer shall be manufactured in a facility approved by an agency accredited by the Forest Stewardship Council.

2. Paint and primer:

a. Refer to Section 01350 – Special Environmental Requirements.

b. Refer to Section 9910 – Paints.

G. Recyclability: Project goal is to provide products that are 100 percent recyclable or reusable.

2.2 SOURCE QUALITY CONTROL:

A. Indoor Air Quality Issues:

1. Window shall be shop-primed and painted. *(Note 1.8)*
2. For touch-up in field refer to Section 01350- Special Environmental Requirement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Product shall be examined for damage, signs of warping, denting or splitting and replaced immediately. Products with signs of any damage, mildew, and other contamination before installation. Products with any such damage or contamination shall be rejected. *(Note 1.9)*

B. Gaskets with gaps or other visible installation irregularities on window units delivered to site shall be corrected by manufacturer. *(Note 1.9)*

C. Examine all window frames opening before product is installed to verify that they are installed plumb, true and level. *(Note 1.10)*

D. Wall space around the frame shall be filled with insulation. *(Note 1.11)*

3.2 INSTALLATION

A. Frame product shall be set plumb, square, aligned and without twist at correct elevation. Product shall be tightly fitted to the opening, rigidly secured in place and properly braced. *(Note 1.10)*

B. [Vinyl] nailing fins shall be used on frame exterior to form a weather tight perimeter. *(Note 1.6)*

C. Sill members shall be set with joint fillers or gaskets to provide weather tight construction. *(Note 1.6)*

3.3 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the site waste management program, section 01565.

END OF SECTION

NOTES

SECTION 08550 – WOOD-FRAMED WINDOWS – NOTES

JUSTIFICATION

1.1 Windows are a source of daylighting, and can reduce lighting loads in a commercial application. Daylighting has been associated with increased productivity and better health.

1.2 Wood-framed windows typically have lower conductivity than metal-framed windows without thermal breaks. Windows with low thermal transmittance (u-factor) reduce energy consumption in a building. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method. Most climate zones in California require double-glazed windows. Insulated glass and thermal breaks lower thermal transmission from the exterior to the interior.

1.3 A lower SHGC contributes to energy efficiency in a cooling dominated climate and a higher SHGC for a heating dominated climate. A low SHGC is recommended for California climates. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method.

1.4 High visible transmittance is preferred for daylighting purposes. Typically, high visible light transmittance is associated with a higher SHGC, which is not desirable in most California climate zones. Select glazing that has a high visible light transmittance and low SHGC for most California climate zones. High performance glazing has a low SHGC and high visible light transmittance, which is ideal for daylighting and cooling benefits. High performance glass lowers radiant heat transfer from the exterior to the interior, without greatly compromising the visible light transmittance.

1.5 Reducing air infiltration reduces heating and cooling energy. Weatherstripping or using sealants ensures a weather tight system. The laser weld does not use filler material and is more uniform. It also ensures the most precise edge in the market. Both these factors ensure that there is minimal energy loss through infiltration. The laser edge does not use any grinding and stays stronger for a longer period of time, which maximizes the usability of the product.

1.6 As with other building products made from wood, the source of that wood should be an important consideration. Theoretically wood comes from a renewable source when sourced from a well-managed forest and has very low embodied energy. Wood that is certified to be from a well-managed resource lowers environmental impact. Wood products that are not sourced from well-managed forests have an enormous environmental impact.

However, only few manufacturers offer wood framed windows made out of certified wood, or offer it as a special-order option. It is recommended that

NOTES

certified wood should be used whenever it is relatively easy and economical to incorporate them.

1.7 Insulated glass has a lower thermal conductance than monolithic glass.

1.8 Field painting is not desirable due to indoor air quality issues.

1.9 Any irregularity or damage to the edges will prevent a tight fit, and increase infiltration. This will contribute to increase in heating and cooling energy.

1.10 If the openings or frame are not plumb and level, or the corners do not meet at right angles, the product and the opening will not fit tightly, making it susceptible to energy loss through air infiltration.

1.11 Filling the wall space around the frame with insulation ensures thermal integrity of the walls and the storefront.

APPLICABILITY

2.1 Commercial application of windows.

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Energy Efficient Windows by Andersen Windows, Inc. http://commercial.andersenwindows.com

4.2 Energy Efficient Windows by Kolbe and Kolbe Millworks Company.

4.3 “Loewen Heat-Smart” extruded aluminum-clad wood windows.

4.4 Pella’s SmartSah wood windows uses certified/fast-growing wood for the frames. http://www.pella.com

4.5 “Teton” series wood windows by Norco Window Company.

4.6 "Ariel" aluminum clad windows by Peachtree doors and windows.

4.7 Reuse and total recycling systems by Urban Ore, Inc. Berkeley, CA

4.8 “Renewal” program for retrofitting existing buildings and reusing old materials by Andersen Windows, Inc. http://www.renewalbyandersen.com/flash/index.html

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 http://www.afsonl.com/products. (Building product information).

RELATED SPECIFICATION SECTIONS

6.1 06070 – Wood Treatment

6.2 06080 – Factory Applied wood coating

6.3 06650 – Plastics

6.4 08410 – Metal-framed storefronts

NOTES

6.5 08520 – Aluminum Windows

6.6 08560 – Plastic-framed Windows

6.7 08565 – Glass-Fiber-Framed Windows

6.8 08620 – Unit Skylights

6.9 08630 – Metal-framed skylights

6.10 08810 – Glass

SECTION 08620 – UNIT SKYLIGHTS

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. °F.

B. SHGC (Solar Heat Gain Coefficient): The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

C. Visible Light Transmittance (T_{VIS}): Percentage of incident light energy transmitted by glazing.

1.2 SYSTEM DESCRIPTION

A. Plastic-glazed unit skylights installed to maintain specified thermal performance.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Manufactured [insulated] unit skylights with plastic glazing. *(Note 1.2)*

1. [Insulated] Curb-mounted Skylight.
2. [Insulated] Roof-mounted Skylight.

B. Performance Requirements:

1. U-factor shall be rated, certified and labeled in accordance with NFRC 100.

a. U-Factor of skylight assembly shall not be greater than ____ Btu/hr. sq. ft. °F. *(Note 1.3)*

2. SHGC shall be rated, certified and labeled in accordance with NFRC 200.
   a. SHGC of skylight assembly shall not be greater than ____. *(Note 1.4)*
3. Glazing: Visible light transmittance shall be rated, certified and labeled in accordance with NFRC 300.
   a. Visible light transmittance shall not be less than ____. *(Note 1.5)*
4. Skylight assembly: Air leakage shall be rated, certified and labeled in accordance with NFRC 400, and shall not exceed 0.4 cfm/sq. ft. *(Note 1.6)*

C. Recycled Content: *(Note 1.7)*
   1. Aluminum frames: Minimum 75% post-consumer recycled content.
   2. Steel frames: Minimum 17% post-consumer recycled content, 35% total recycled content.

D. All points of contact between the operable and non-operable components of the skylight shall be weatherstripped. *(Note 1.6)*

E. Corners shall be sealed against air and water infiltration.

F. Glazing: [Double][Acrylic] [Polycarbonate] plastic glazing. *(Note 1.2)*
   1. Glazing shall have weatherproofing gaskets on both sides. *(Note 1.6)*

G. Frame: [Metal]
   1. All junctions between glazing and frame shall be sealed with weather tight sealant. *(Note 1.6)*
   2. Inner frame shall have a continuous [rigid foam] [fiberglass batt] thermal break, to completely isolate it from exterior frame. *(Note 1.8)*
   3. A continuous thermal break shall be present between any two metal [or any other highly conductive material] surfaces, when one is faces the external environment and the other faces the interior space. *(Note 1.8)*
   4. Curb-mounted skylight: Curb frame shall be thermally broken. *(Note 1.8)*

H. Paint and primer: [Edit to suit project]
   1. Refer to Section 01350 – Special Environmental Requirements.
   2. Refer to Section 9910 – Paints.

I. Moisture control:
   1. Skylights shall have integral condensation gutter and weep holes for draining any moisture to the outside.

J. Recyclability: Project goal is to provide products that are 100 percent [recyclable] [re-useable].

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:
   1. Doors shall be shop primed and finished. *(Note 1.9)*
   2. For touch-up in field refer to Section 01350 – Special Environmental Requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Product shall be examined for damage, signs of warping, or denting and replaced immediately. Products with signs of any damage, mildew, and other contamination before installation contamination shall be rejected. *(Note 1.10)*

B. Gaskets with gaps or other visible installation irregularities on skylight units delivered to site shall be corrected by manufacturer. *(Note 1.10)*

C. [Roof mounted units with high curbs]: Skylight installer shall inspect the supporting deck for completeness and water-tightness to verify that they are properly prepared to receive the work. Any deficiencies in the substrate shall be reported and rectified. Work shall not proceed until all deficiencies have been rectified.

D. [Curb mounted units]: Installer shall inspect the supporting curbs for completeness and water-tightness to verify that they are properly prepared to receive the work. Any deficiencies in the substrate shall be reported and rectified. Work shall not proceed until all deficiencies have been rectified.

3.2 INSTALLATION

A. Co-ordinate installation with adjacent work such as roofing, sheet metal and other work to ensure creation of a complete weatherproof assembly.

3.3 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the site waste management program, section 01565.

END OF SECTION

N
O
T
E
S

SECTION 08620 – UNIT SKYLIGHTS – NOTES

JUSTIFICATION

1.1 Skylights are a source of daylighting, and can reduce lighting loads in a commercial application. Daylighting has been associated with increased productivity and better health.

1.2 Insulated glazing panels have a lower thermal conductance than monolithic glass

1.3 Windows with low thermal transmittance (u-factor) reduce energy consumption in a building. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method. Most climate zones in California require double-glazed windows. Insulated glass and thermal breaks lower thermal transmission from the exterior to the interior.

1.4 A lower SHGC contributes to energy efficiency in a cooling dominated climate and a higher SHGC for a heating dominated climate. A low SHGC is recommended for California climates. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method.

1.5 High visible transmittance is preferred for daylighting purposes. Typically, high visible light transmittance is associated with a higher SHGC, which is not desirable in most California climate zones. Select glazing that has a high visible light transmittance and low SHGC for most California climate zones. High performance glazing has a low SHGC and high visible light transmittance, which is ideal for daylighting and cooling benefits. High performance glass lowers radiant heat transfer from the exterior to the interior, without greatly compromising the visible light transmittance.

1.6 Reducing air infiltration reduces heating and cooling energy. Weatherstripping or using sealants ensures a weather tight system.

1.7 Manufacturing process for metal products is energy intensive. High recycled content reduces energy used during manufacture.

1.8 Thermal breaks reduce energy consumption by reducing thermal conduction between the interior and exterior surfaces.

1.9 Field painting is not desirable due to indoor air quality issues.

1.10 Any irregularity or damage to the edges will prevent a tight fit, and increase infiltration. This will contribute to increase in heating and cooling energy.

APPLICABILITY

2.1 Commercial applications of skylights.

N O T E S

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Energy efficient unit skylight by Plasteco Inc. http://www.plasteco.com/

4.2 Energy efficient unit skylight by Wasco Products Inc. http://www.wasco1.com/

4.3 Energy efficient unit skylights by Therma-Vu. http://www.thermo-vu.com/

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 http://www.afsonl.com/products. (Building product information).

RELATED SPECIFICATION SECTIONS

6.1 06065 – Plastic Materials

6.2 08560 – Plastic Windows

6.3 08630 – Metal skylights

6.4 08810 – Glass

SECTION 08630 – METAL-FRAMED SKYLIGHTS

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. °F.

B. SHGC (Solar Heat Gain Coefficient): The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

C. Visible Light Transmittance (T_{VIS}): Percentage of incident light energy transmitted by glazing.

1.2 SYSTEM DESCRIPTION

A. Provide metal-framed skylight with [insulated] glazing which have been installed to maintain energy efficiency criteria as per 2001 Title-24 Standard without defects, damage or failure.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Metal-framed skylights with [insulated] glass panel. *(Note 1.2)*

B. Performance Requirements:

1. Metal-framed skylight: U-factor shall be rated, certified and labeled in accordance

with NFRC 100.

a. U-Factor of skylight assembly shall not be greater than ____ Btu/hr. sq. ft. °F. *(Note 1.3)*

2. Metal-framed skylight: SHGC shall be rated, certified and labeled in accordance with NFRC 200.
   a. SHGC of skylight assembly shall not be greater than ____. *(Note 1.4)*
3. Glass: Visible light transmittance shall be rated, certified and labeled in accordance with NFRC 300.
   a. Visible light transmittance shall not be less than ____. *(Note 1.5)*
4. Metal framed skylight assembly (including glass, sash and frame): Air leakage shall be rated, certified and labeled in accordance with NFRC 400, and shall not exceed 0.4 cfm/sq. ft. *(Note 1.6)*

C. Recycled Content:*(Note 1.6)*

1. Auminum frames: Minimum 75% post-consumer recycled content.
2. Steel frames: Minimum 35% total recycled content, 17% of which shall be post-consumer recycled content.

D. Glazing Panel: [Insulated] [Monolithic]*(Note 1.2)*

1. Glass type: [Clear] [Tinted] [High performance tint] [Low-e coating]. Refer Section 8810 – Glass. *(Note 1.5)*
2. Color of tint: [Specify only if applicable] Refer Section 8810 – Glass
3. Center of Glass U-factor: Refer Section 8810 – Glass.
4. Solar Heat Gain Coefficient: Refer Section 8810 – Glass.
5. Visible Transmittance: Refer Section 8810 – Glass
6. Glazing panel shall have a double weather seal. *(Note 1.6)*

E. Frame: [Metal]

1. All junctions between glazing and frame shall be sealed with weather tight sealant. *(Note 1.6)*
2. Inner frame shall have a continuous [rigid foam] [fiberglass batt] thermal break, to completely isolate it from exterior frame. *(Note 1.8)*
3. A continuous thermal break shall be present between any two metal [or any other highly conductive material] surfaces, when one is faces the external environment and the other faces the interior space. *(Note 1.8)*

F. Finishes:

1. Refer to Section 01350 – Special Environmental Requirements.
2. Refer to Section 9910 – Paints.

G. Moisture control:

1. Shall be integrated with flush condensation gutters.
2. Framing system shall be capable of collecting and draining condensation and water infiltration to the exterior through weepholes or drain tubes in the sill or perimeter framing members.
3. All expansion joints in the sill member shall be slotted for thermal movement, and sealed against moisture and air infiltration.
4. The sill member shall not be penetrated with either rafter connections or anchors

to the support and adjacent construction.

H. Recyclability: Project goal is to provide skylight components that are 100% recyclable/reusable.

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:

1. Doors shall be shop primed and finished. *(Note 1.9)*
2. For touch-up in field refer to Section 01350 – Special Environmental Requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. In-place structure, anchors and attachments shall be adequate and properly prepared to specified tolerances prior to installing skylight. Skylight shall not be installed until defects are corrected. *(Note 1.10)*

3.2 INSTALLATION

A. Glazing shall have weatherproofing gaskets on both sides. *(Note 1.6)*

B. All junctions between glazing and metal frame shall be sealed with a sealant or have a weatherproofing gasket. *(Note 1.6)*

C. Rafter, purlin and sill glazing caps shall be secured with thermally broken glazing clips. *(Note 1.8)*

D. Curb shall have continuous thermal break. *(Note 1.8)*

E. Weatherproof sealant shall be applied to seal horizontal joints between glass panels and silicone sealant to wet seal joints between retainers and glass. *(Note 1.6)*

F. Sealants shall be applied to all metal to metal joints. *(Note 1.6)*

3.3 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the site waste management program, section 01565.

END OF SECTION

N
O
T
E
S

SECTION 08630 – METAL-FRAMED SKYLIGHTS - NOTES

JUSTIFICATION

1.1 Skylights are a source of daylighting, and can reduce lighting loads in a commercial application. Daylighting has been associated with increased productivity and better health.

1.2 Double-glazed skylights have a lower thermal transmittance (U-factor) compared to a single glazed one.

1.3 Metal framed skylights have a higher thermal transmittance than those with plastic or polycarbonate frames, unless they are thermally broken. Skylights with low thermal transmittance (u-factor) reduce energy consumption in a building. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method. Most climate zones in California require double-glazed windows. Insulated glass and thermal breaks lower thermal transmission from the exterior to the interior.

1.4 A lower SHGC contributes to energy efficiency in a cooling dominated climate and a higher SHGC for a heating dominated climate. A low SHGC is recommended for California climates. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method.

1.5 High visible transmittance is preferred for daylighting purposes. Typically, high visible light transmittance is associated with a higher SHGC, which is not desirable in most California climate zones. Select glazing that has a high visible light transmittance and low SHGC for most California climate zones. High performance glazing has a low SHGC and high visible light transmittance, which is ideal for daylighting and cooling benefits. High performance glass lowers radiant heat transfer from the exterior to the interior, without greatly compromising the visible light transmittance.

1.6 Reducing air infiltration reduces heating and cooling energy. Weatherstripping or using sealants ensures a weather tight system.

1.7 Manufacturing process for metal products is energy intensive. High recycled content reduces energy used during manufacture.

1.8 Metal framing members have very high conductivity and can increase energy consumption in a building. unless fitted with thermal break. Thermal breaks reduce energy consumption by reducing thermal conduction between the interior and exterior surfaces.

1.9 Field painting is not desirable due to indoor air quality issues.

1.10 Any irregularity or damage to the edges will prevent a tight fit, and increase infiltration. This will contribute to increase in heating and cooling energy.

REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY

APPLICABILITY

2.1 Large scale commercial applications of skylights.

COST IMPACT

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Photovoltaic powered daylighting system by Natural Lighting Co., Inc. http://www.daylighting.com/

4.2 Active daylighting system by So-Luminaire Daylighting System Corp.

4.3 Prismatic skylights by SunOptics Skylights. http://www.sunoptics.com/

4.4 Custom skylights by Super Sky Products Inc. http://www.supersky.com/

4.5 Metal skylights by Skywall Translucent systems. http://www.skywall.com

4.6 Naturalite system by Vistawall Architectural Products. http://www.vistawall.com

4.7 Metal framed skylights by TRACO Skytech Systems®, Inc. http://www.tracowindows.com/

REFERENCES FOR MORE INFORMATION

5.1 California Energy Commission. 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000).

5.2 http://www.afsonl.com/products. (Building product information).

RELATED SPECIFICATION SECTIONS

6.1 08620 – Unit skylights

6.2 08810 – Glass

SECTION 08810 – GLASS

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. ° F.

B. SHGC (Solar Heat Gain Coefficient): The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

C. Visible Light Transmittance (T_{VIS}): Percentage of incident light energy transmitted by glazing.

1.2 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.3 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: [Insulated glazing] [Monolithic glazing] *(Note 1.2)*

B. Performance requirements:

1. Glazing U-factor shall be rated in accordance with NFRC 100.
   a. Center of glass U-factor: Shall not exceed ____ Btu/ hr. sq. ft. °F. *(Note 1.2)*
2. Glazing Solar Heat Gain Coefficient shall be rated in accordance with NFRC 200.
   a. SHGC: Shall not exceed ____ *(Note 1.3)*.
3. Visible light transmittance shall be rated in accordance with NFRC 300.
   a. Visible light transmittance shall not be less than ____. *(Note 1.4)*

PART 3 - EXECUTION

3.1 INSTALLATION

A. Glass edges shall be protected from moisture by using either suitable impervious weather seal, or an adequate weep hole system. *(Note 1.5)*

3.2 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the site waste management program, section 01565.

END OF SECTION

NOTES

SECTION 08810 – GLASS – NOTES

JUSTIFICATION

1.1 Apart from providing a visual connection to the external environment, glazing also provides daylighting in buildings. However, glazing can also increase the cooling load in a building considerably by transmitting and trapping solar gains inside the building.

1.2 Insulated glass (double-pane) has a lower thermal transmittance than monolithic glass. Glass with low thermal transmittance (U-factor) reduce energy consumption in a building. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method. Most climate zones in California require double-glazed windows. Insulated glass and thermal breaks lower thermal transmission from the exterior to the interior.

1.3 A lower SHGC contributes to energy efficiency in a cooling dominated climate and a higher SHGC for a heating dominated climate. A low SHGC is recommended for California climates. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method.

1.4 Daylighting contributes towards significant energy savings in commercial buildings by reducing energy consumption and internal loads due to artificial lighting. High visible transmittance is preferred for daylighting purposes. Typically, high visible light transmittance is associated with a higher SHGC, which is not desirable in most California climate zones. Select glazing that has a high visible light transmittance and low SHGC for most California climate zones.

Tinted glass is glazing that is not clear and has a color to it – such as blue, green, gray etc. A dark tint typically has a lower SHGC and VLT than a lighter tint. High performance tinted glass reduces solar heat gain to below that of of a dark tint (such as bronze or gray tint) but has a visible transmittance closer to clear glass. High-performance or spectrally selective tinted glass products are typically light green or light blue. The tint has no effect on the U-factor but reduces solar gain, which is a benefit in the summer and a liability in the winter depending on local climate conditions.. High performance glass lowers radiant heat transfer from the exterior to the interior, without greatly compromising the visible light transmittance. Spectrally selective coatings/glazing controls the type of solar radiation admitted and blocked from the inside to the outside. Selecting glazing type that most effectively filters out the ultra violet and infra red radiation (and even eliminates some of the extreme ends of the visible solar spectrum) is best suited for cooling dominated climates select. The best spectral selectivity for heating dominated climates is one that has a high transmittance over the entire solar spectrum, admitting the most solar radiant heat, and a low emissivity (high reflectivity) over the long-wave infra red radiation spectrum, to reflect radiant heat

N O T E S

from the walls and room furnishings back into the building.

TABLE 1 - OPTICAL AND THERMAL PROPERTIES OF GLAZING

Glazing Type	VLT	ASHRAE U-Value		SHGC	VLT/SHGC
		Winter	Summer		
Clear Uncoated monolithic glass	85%	1.09	1.09	0.81	1.05
Tinted Uncoated Monlithic Glass (Gray)	44%	1.09	1.10	0.57	0.77
Tinted Uncoated Monlithic Glass (Bronze)	54%	1.09	1.09	0.62	1.19
Tinted Uncoated Monlithic Glass (Green)	74%	1.09	1.09	0.58	0.95
Tinted Uncoated Monlithic Glass (Blue)	55%	1.09	1.10	0.58	1.29
High Performance Tinted Uncoated Monlithic Glass (Blue-green)	75%	1.09	1.09	0.62	1.15
High Performance Tinted Uncoated Monlithic Glass (Azulite)	71%	1.09	1.11	0.51	1.39
Tinted Uncoated Monlithic Glass (EverGreen)	66%	1.09	1.11	0.51	1.29
Clear Uncoated Insulated Glass	78%	0.48	0.57	0.70	1.11
Tinted Uncoated Insulated Glass (Gray)	39%	0.48	0.57	0.47	0.83
Tinted Uncoated Insulated Glass (Bronze)	48%	0.48	0.57	0.45	1.07
Tinted Uncoated Insulated Glass (Green)	66%	0.48	0.57	0.50	1.32
Tinted Uncoated Insulated Glass (Blue)	49%	0.48	0.57	0.46	1.07
High Performance Tinted Uncoated Insulated Glass (Blue-green)	67%	0.48	0.57	0.50	1.34
High Performance Tinted Uncoated Insulated Glass (Azurlite)	63%	0.48	0.57	0.40	1.58
High Performance Tinted Uncoated Insulated Glass (EverGreen)	59%	0.48	0.57	0.39	1.51
Clear Low-e Coated Insulating Glass (High VT)	70%	0.31	0.37	0.53	1.32
Clear Low-e Coated Insulating Glass (Medium VT)	50%	0.31	0.35	0.39	1.28
Clear Low-e Coated Insulating Glass (Low VT)	30%	0.31	0.34	0.27	1.11
Tinted Coated Low-e Insulating Glass (Gray - High VT)	40%	0.31	0.32	0.33	1.21
Tinted Coated Low-e Insulating Glass (Gray - Medium VT)	25%	0.31	0.34	0.24	1.04
Tinted Coated Low-e Insulating Glass (Gray - Low VT)	20%	0.31	0.34	0.21	0.95
Tinted Coated Low-e Insulating Glass (Bronze - High VT)	45%	0.31	0.32	0.37	1.22
Tinted Coated Low-e Insulating Glass (Bronze - Medium VT)	28%	0.31	0.34	0.27	1.04
Tinted Coated Low-e Insulating Glass (Bronze - Low VT)	20%	0.31	0.34	0.20	1.00
Tinted Coated Low-e Insulating Glass (Green - High VT)	60%	0.31	0.32	0.38	1.58
Tinted Coated Low-e Insulating Glass (Green - Medium VT)	43%	0.31	0.35	0.28	1.54
Tinted Coated Low-e Insulating Glass (Green - Low VT)	30%	0.31	0.34	0.22	1.36
Tinted Coated Low-e Insulating Glass (Blue - High VT)	38%	0.31	0.32	0.35	1.09
Tinted Coated Low-e Insulating Glass (Blue - Medium VT)	28%	0.31	0.35	0.24	1.17
Tinted Coated Low-e Insulating Glass (Blue - Low VT)	18%	0.31	0.34	0.19	0.95
High Performance Tinted Coated Low-e Insulating Glass (Blue-green - High VT)	60%	0.31	0.32	0.39	1.54
High Performance Tinted Coated Low-e Insulating Glass (Blue-green - Med. VT)	40%	0.31	0.33	0.29	1.38
High Performance Tinted Coated Low-e Insulating Glass (Blue-green - Low VT)	30%	0.31	0.34	0.24	1.25
High Performance Tinted Coated Low-e Insulating Glass (Azurlite - High VT)	55%	0.31	0.34	0.32	1.72
High Performance Tinted Coated Low-e Insulating Glass (Azurlite - Medium VT)	37%	0.31	0.34	0.25	1.48
High Performance Tinted Coated Low-e Insulating Glass (Azurlite - Low VT)	29%	0.31	0.34	0.19	1.53
High Performance Tinted Coated Low-e Insulating Glass (EverGreen - High VT)	53%	0.31	0.33	0.31	1.71
High Performance Tinted Coated Low-e Insulating Glass (EverGreen - Med. VT)	35%	0.31	0.34	0.24	1.46
High Performance Tinted Coated Low-e Insulating Glass (EverGreen - Low VT)	24%	0.31	0.34	0.18	1.33

1.5 Reducing air infiltration reduces heating and cooling energy. Weatherstripping or using sealants ensures a weather tight system.

APPLICABILITY

2.1 Commercial application of glazing with high thermal and optical performance.

COST IMPACT

3.1 Costs vary, but high performance low-e coatings add about $2.00 to $3.00 per square foot to the cost of a double-pane glazing. A spectrally selective blue or green tint may add about $1.00 to $2.00 per square foot.

NOTES

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Viracon. http://www.viracon.com/

4.2 PPG Industries Corporate. http://www.ppg.com/

4.3 Pilkington. http://www.pilkington.com/

REFERENCES FOR MORE INFORMATION

5.1 http://www.nfrc.org/ (Fenestration rating standard)

RELATED SPECIFICATION SECTIONS

6.1 08410 – Metal-framed storefronts

6.2 08520 – Aluminum windows

6.3 08550 – Wood-framed windows

6.4 08620 – Unit skylights

6.5 08630 – Metal-framed skylights

6.6 08910 – Metal-framed curtain wall

SECTION 08910 – METAL-FRAMED CURTAIN WALL

PART 1 - GENERAL

1.1 DEFINITIONS

A. U-Factor (Thermal Transmittance): Heat transmission in unit time through unit area of a material or construction and the boundary of air films, induced by unit temperature difference between the environments on each side. It is measured in Btu/ hr. sq. ft. °F.

B. SHGC (Solar Heat Gain Coefficient): The ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted or convected into the space.

1.2 SYSTEM DESCRIPTION

A. Provide metal framed curtain walls with [insulated] glazing installed to maintain specified thermal criteria.

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS

Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.

1.4 QUALITY ASSURANCE

A. Environmental issues: Refer to Section 01350 – Special Environmental Requirements.

1.5 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 01350 – Special Environmental Requirements.

B. Refer to Section 01565 – Site Waste Management Program.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description: Metal-framed curtain wall with [insulated] glass. *(Note 1.2)*

B. Performance Requirement:

1. Curtain wall shall be Energy Star compliant.
2. Metal-framed curtain wall: U-factor of the transparent portion of the metal framed curtain wall assembly (including glass and frame) shall be rated in accordance with NFRC 100.

a. U-factor of curtain wall assembly shall not be greater than ____. Btu/hr. sq. ft. °F. *(Note 1.2)*

3. Metal-framed curtain wall: SHGC of the visible portion of the metal framed curtain wall assembly (including glass and frame) shall be rated in accordance with NFRC 200.
   a. Solar Heat Gain Factor (SHGC) of curtain wall assembly shall not be greater than ____. *(Note 1.3)*
4. Glass: Visible light transmittance shall be rated in accordance with NFRC 300.
   a. Visible light transmittance shall not be less than ____. *(Note 1.4)*
5. Metal framed curtain wall assembly (including glass, sash and frame): Air leakage shall be rated in accordance with NFRC 400, and shall not exceed 0.4 cfm/sq. ft. *(Note 1.5)*

C. Recycled Content: *(Note 1.6)*
   1. Aluminum frames: Minimum 75% post-consumer recycled content.
   2. Steel frames: 17% post-consumer recycled content, total 35% total recycled content.

D. Glazing Panel: [Insulated glass] *(Note 1.2)*
   1. Glass type: [Clear] [Tinted] Refer to Section 8810 – Glass
   2. Color of tint: [Specify only if applicable] Refer to Section 8810 – Glass
   3. Center of Glass U-factor: Refer to Section 8810 – Glass
   4. Solar Heat Gain Coefficient: Refer to Section 8810 – Glass
   5. Visible Transmittance: Refer to Section 8810 – Glass
   6. Glazing panel shall have a double weather seal. *(Note 1.5)*
   7. Glazed curtain wall shall include waterproof spacer and sealant at the structural joint. *(Note 1.5)*

E. Mullions: Shall be thermally broken. *(Note 1.7)*

F. Frame: [Steel] [Aluminum]
   1. All points of contact between the operable and non-operable components of the door shall be weatherstripped. If weatherstripping is not used, the edge shall be welded using laser technology. *(Note 1.5)*
   2. A continuous thermal break shall be present between any two metal [or any other highly conductive material] surfaces when one faces the external environment and the other faces the interior. *(Note 1.7)*
   3. Thermally broken sections shall not be assembled by means of screws, gammets or other fasteners. *(Note 1.8)*
   4. Where thermally broken welded frame product is specified, welds shall not cause thermal transfers between exterior and interior surfaces. *(Note 1.8)*

G. Glazing Panel: *(Note 1.4)*
   1. Glass type: [Clear] [Tinted] [high performance tint] Refer to Section 8810 – Glass *(Note 1.4)*
   2. Color of tint: [Specify only if applicable] Refer to Section 8810 – Glass
   3. Center of Glass U-factor: Refer to Section 8810 – Glass
   4. Solar Heat Gain Coefficient: Refer to Section 8810 – Glass

5. Visible Transmittance: Refer to Section 8810 – Glass
6. Glazing panel shall have a double weather seal. *(Note 1.5)*

H. Finish and primer:

1. Refer to Section 01350 – Special Environmental Requirements.
2. Refer to Section 9910 – Paints.

I. System shall have adequate drainage channels to drain the water entering the joints and condensation occurring within the system through drain holes and gutters of adequate size to the exterior surface of the wall. There shall be no moisture or air penetration through the curtain wall.

J. Recyclability: Project goal is to provide products that are 100 percent recyclable or reusable.

2.2 SOURCE QUALITY CONTROL

A. Indoor Air Quality Issues:

1. Window shall be shop-primed and painted. *(Note 1.9)*
2. For touch-up in field refer to Section 01350- Special Environmental Requirement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Metal framed curtain wall components shall be examined for damage, signs of warping, denting or splitting and replaced immediately. Products with signs of any damage, mildew, and other contamination before installation shall be rejected. *(Note 1.10)*

B. Gaskets with gaps or other visible installation irregularities on framing delivered to site shall be corrected by manufacturer. *(Note 1.10)*

C. Examine all wall openings before product is installed to verify that they are installed plumb, true and level. *(Note 1.11)*

D. Wall space around the frame shall be filled with insulation. *(Note 1.12)*

3.2 INSTALLATION

A. Frame product shall be set plumb, square, aligned and without twist at correct elevation. Product shall be tightly fitted to the opening, rigidly secured in place and properly braced. *(Note 1.10)*

B. Sill members shall be set with joint fillers or gaskets to provide weather tight construction. *(Note 1.5)*

3.3 CLEANING

A. Final cleaning shall be as described in section 01350.

B. Remove and recycle excess material as required by the site waste management program, section 01565.

END OF SECTION

N
O
T
E
S

SECTION 08910 – METAL-FRAMED CURTAIN WALL – NOTES

JUSTIFICATION

1.1 Windows are a source of daylighting, and can reduce lighting loads in a commercial application. Daylighting has also been associated with health and productivity benefits.

1.2 Metal framed curtain walls typically have very high conductivity and can increase energy consumption in a building. Windows with low thermal transmittance (u-factor) reduce energy consumption in a building. Insulated glass has lower thermal conductance than monolithic glass. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method. Most climate zones in California require double-glazed windows. Insulated glass and thermal breaks lower thermal transmission from the exterior to the interior.

1.3 A lower SHGC contributes to energy efficiency in a cooling dominated climate and a higher SHGC for a heating dominated climate. A low SHGC is recommended for California climates. See Table 1-H or Table 1-I of 2001 Energy Efficiency Standards For Residential And Nonresidential Buildings (adopted pursuant to Assembly Bill 970, Statutes of 2000), by the California Energy Commission. These tables contain the minimum thermal performance required for a building to comply with the California energy code using the prescriptive method.

1.4 High visible transmittance is preferred for daylighting purposes. Typically, high visible light transmittance is associated with a higher SHGC, which is not desirable in most California climate zones. Select glazing that has a high visible light transmittance and low SHGC for most California climate zones. High performance glazing has a low SHGC and high visible light transmittance, which is ideal for daylighting and cooling benefits. High performance glass lowers radiant heat transfer from the exterior to the interior, without greatly compromising the visible light transmittance.

1.5 Reducing air infiltration reduces heating and cooling energy. Weatherstripping or using sealants ensures a weather tight system. The laser weld does not use filler material and is more uniform. This ensures that there is minimal energy loss through infiltration. The laser edge does not use any grinding and stays stronger for a longer period of time, which maximizes the usability of the product.

1.6 Manufacturing process for metal products is energy intensive. Recycled content in each of the components saves resources, lowers energy consumed during the manufacturing process.

1.7 Thermal breaks reduce energy loss from the interior surface to the exterior.

1.8 Fastening screws or using other conductive fasteners form thermal bridges and increase thermal conduction between the indoor and outdoor.

1.9 Field painting is not desirable due to indoor air quality issues.

N
O
T
E
S

1.10 Any irregularity or damage to the edges will prevent a tight fit, and increase infiltration. This will contribute to increase in heating and cooling energy.

1.11 If the openings or frame are not plumb and level, or the corners do not meet at right angles, the product and the opening will not fit tightly, making it susceptible to energy loss through air infiltration.

1.12 Filling the wall space around the frame with insulation ensures thermal integrity of the walls and the storefront.

APPLICABILITY

2.1 Commercial application of metal-framed curtain walls.

COST IMPACT

3.1 Refer to Section 08810 – Glass

3.2 Adding a thermally broken frame adds about $ 2.55 per square foot.

EXAMPLE PRODUCTS AND MANUFACTURERS

4.1 Amarlite™ Entrance Framing System, Amarlite™ Glazed Aluminum Curtain Wall Systems by Arch Aluminum & Glass http://www.arch.amarlite.com

REFERENCES FOR MORE INFORMATION

5.1 http://www.nfrc.org/ (Fenestration rating standard)

RELATED SPECIFICATION SECTIONS

6.1 08410 – Metal-framed storefronts

6.2 08520 – Aluminum windows

6.3 08550 – Wood-framed windows

6.3 08620 – Unit skylights

6.4 08630 – Metal-framed skylights

6.5 08810 – Glass

CONTENTS

CONTENTS 1
DISCLAIMER 2
SECTION 09200 – GYPSUM WALLBOARD SYSTEMS 3
SECTION 09200 – GYPSUM WALLBOARD SYSTEMS – NOTES 5
SECTION 09310 – CERAMIC TILE 6
SECTION 09310 – CERAMIC TILE – NOTES 7
SECTION 09500 – ACOUSTICAL CEILINGS 8
SECTION 09500 – ACOUSTICAL CEILINGS – NOTES 10
SECTION 09650 – RESILIENT FLOORING 11
SECTION 09650 – RESILIENT FLOORING – NOTES 13
SECTION 09680 – CARPET 14
SECTION 09680 – CARPET – NOTES 16
SECTION 09720 – WALL COVERING 17
SECTION 09720 – WALLCOVERING – NOTES 19
SECTION 09750 – STONE FACING 20
SECTION 09750 – STONE FACING – NOTES 21
SECTION 09910 – PAINTS 22
SECTION 09910 – PAINTS – NOTES 23
SECTION 10270 – ACCESS FLOORING 24
SECTION 10270 – ACCESS FLOORING – NOTES 25
SECTION 12484 – FLOOR MATS AND FRAMES 26
SECTION 12484 – FLOOR MATS AND FRAMES – NOTES 27
SECTION 12490 – WINDOW SHADES 28
SECTION 12490 – WINDOW SHADES – NOTES 29
SECTION 12500 – FURNITURE 30
SECTION 12500 – FURNITURE – NOTES 32
SECTION 12510 – OFFICE SYSTEMS FURNITURE 33
SECTION 12510 – OFFICE SYSTEMS FURNITURE – NOTES 34
SECTION 12520 – SEATING 35

DISCLAIMER

The authors have tried to make the information in this document as accurate and useful as possible. However, they make no warranty, express or implied, and assume no legal liability for the information in this report. References to specific manufacturers or products are provided for the convenience of the reader and shall not be considered endorsements.

These specifications were prepared as a 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 warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

SECTION 09200 – GYPSUM WALLBOARD SYSTEMS

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of recycled content, and indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. Emission test data is required only if gypsum board with recycled content is provided. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.2 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

B. Mold and mildew prevention:

1. Refer to Section 01350.1.6.D.1

1.3 SITE CONDITIONS

A. Mold and mildew prevention:

1. Refer to Section 01350.1.6.D.1.

1.4 SEQUENCING

A. Install high-VOC-emitting materials before low-VOC-emitting materials.

PART 2 - PRODUCTS

2.1 MATERIALS

A. WALLBOARD PRODUCTS:

1. GENERAL:

a. At the Contractor's option, provide gypsum board products complying with one of the following options:

i. Option 1: Provide gypsum board with paper faces containing 100%

recycled content paper and gypsum cores containing 0% recycled gypsum (virgin gypsum).

ii. Option 2: Provide gypsum board with paper faces containing 100% post-consumer recycled content paper and gypsum cores containing 10% recycled gypsum content.

b. If Option 2 is selected, provide manufacturer's certification that gypsum board used on the project does not contain:

i. Demolition waste.

ii. Construction and demolition waste gypsum board that is contaminated by mold, mildew, paint, wall coverings, laminates, fasteners, joint compounds, tapes, or adhesives.

iii. Synthetic gypsum.

c. In addition, if Option 2 is selected, provide emission test data as specified in Part 1 of the Section.

B. INDOOR QUALITY TESTS: Test Option 2 gypsum board separately in accordance with the requirements of Section 01350. Submit copies of test reports in accordance with SUBMITTALS Article above.

C. DELIVERY, STORAGE, AND HANDLING:

1. ENVIRONMENTAL REQUIREMENTS: Comply with the packaging, delivery, storage, and handling requirements of Section 01350.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 09200 – GYPSUM WALLBOARD SYSTEMS – NOTES

JUSTIFICATION

1.1 Indoor Air Quality--Testing for TVOCs, IVOCs, SOVOCs, MVOCs, and particulates is required in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not affect Indoor Air Quality.

1.2 Resource efficient materials (recycled content, recyclable, embodied energy, packaging, durability). Reduce impact on landfill and preserve natural resources. Goal: 100% recycled content facing paper.

1.3 Lack of quality control for the recycled core could pose a problem. If demolition waste is used, this could be a source of contamination. Paint, wall coverings, laminates, adhesives, mold, mildew, fasteners, etc. can contribute unknown effects to the gypsum and, in turn, affect indoor air quality.

APPLICATION

2.1 Assembly/system for finishing interior walls.

COST IMPACT

3.1 None. Facing paper contains 100% recycled content by virtually every manufacturer.

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 USG has a plant in Fremont, California which produces boards with no recycled content core. (800) 874-4968

4.2 Domtar Gypsum (Georgia Pacific) has plants in California (non-synthetic gypsum) and in Mid-West (synthetic gypsum). (800) BUILD-GP

4.3 Celotex has a plant in Wyoming. (Jacksonville plant has typical gypsum recycled content of 50% - 90%). (800) 227-1216

SECTION 09310 – CERAMIC TILE

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content.

1.2 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content
1. Provide tile with minimum 77% post consumer recycled content.
2. Provide paver tile with 100% post consumer recycled glass content.

B. Recyclability
1. Tile products shall be 100% recyclable.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 09310 – CERAMIC TILE – NOTES

JUSTIFICATION

1.1 The use of tile with recycled content (usually post industrial glass) conserves natural resources.

1.2 Tiles are durable (extending life span) and some varieties are recyclable.

1.3 Energy expended for recycling tile should be investigated.

1.4 Energy expended for manufacturing recycled content tile should be investigated and balanced with the amount of energy expended for manufacturing new tile.

APPLICATION

2.1 Walls and floors in restrooms, kitchens, “wet” areas. Also used as countertops and other surfacing applications.

COST IMPACT

3.1 $

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Terra Green

4.2 Environmental Stone Products

4.3 Scatter Creek Enterprises (glasscrete pavers)

4.4. Heath Ceramics
(415) 332-3732

SECTION 09500 – ACOUSTICAL CEILINGS

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource Efficient Product Data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Indoor Air Quality: Submit material safety data sheets (MSDS) for the acoustical ceiling panels or tile, the fungicide, biocide, or microbial used in the tile, and emission test data for acoustic ceiling panels. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.
3. Environmental Issues Certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of recyclability, and indoor air quality requirements.
4. Provide test data and other relevant information to prove the efficacy of fungicide, biocide, or microbial as it is applied to the ceiling panels or tile. Such data would include or be similar to ASTM D6329-98, "Standard Guide for Developing Methodology for Evaluating the Ability of Indoor Materials to Support Microbial Growth Using Static Environmental Chambers."

1.2 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Recycled Content:

1. Provide acoustical ceiling tile with a rangeof 79%-85% post consumer recycled content.
2. Provide suspension system with minimum 25% recycled content.

B. Recyclability:

1. Product shall be 100% recyclable.

C. Emission testing criteria:

1. Ceiling panels shall have zero formaldehyde emission when tested per Section 01350.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

SECTION 09500 – ACOUSTICAL CEILINGS – NOTES

JUSTIFICATION

1.1 Indoor Air Quality: Testing for TVOCs, IVOCs, and formaldehyde is recommended in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not adversely affect Indoor Air Quality.

1.2 Resource efficient materials (recycled content, recyclablility, embodied energy, packaging, durability) – acoustical ceiling systems' resource efficiency needs to be evaluated to determine to what extent/how the criteria are met.

APPLICATION

2.1 Lay-in, dropped ceiling panel and support grid applications.

COST IMPACT

3.1 $

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Armstrong, Ultima
2500 Columbia Avenue
Lancaster, PA 17606
717-396-6109
www.ceilings.com

4.2 USG, Astro Clima Plus
125 South Franklin
Chicago, IL 60606-4678
800-USG-4YOU
www.usg.com

SECTION 09650 – RESILIENT FLOORING

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENT REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content and recyclability.
2. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data for resilient flooring and adhesives. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.2 SITE CONDITIONS

A. Provide Temporary Ventilation during installation as required by Section 01350.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Resilient Sheet and Tile Flooring

1. Recycled Content: __% of post-industrial recycled content and __% post-consumer recycled content.
2. Recyclability: 100%. Unused material on site, old material without leveling compounds,adhesive or coatings and scrap material should be returned for recycling.
3. Indoor Air Quality: Provide vinyl-free and chlorine-free resilient tile conforming to the emissions testing requirements of Section 01350:

B. Resilient Flooring Adhesive

1. Indoor Air Quality: Provide low odor, solvent-free, water-based contact adhesives.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

SECTION 09650 – RESILIENT FLOORING – NOTES

JUSTIFICATION:

1.1 Indoor Air Quality: Testing for TVOCs, IVOCs, and formaldehyde is recommended in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not adversely affect Indoor Air Quality.

1.2 Resource efficient materials (recycled content, recyclable, embodied energy, packaging, durability)—Flooring products with recycled content and that are recyclable are becoming more available and reduce the need for virgin materials. The amount of recycled content will need to be confirmed by the architect and should be based on what is currently available in the marketplace.

APPLICATION

2.1 Horizontal applications (flooring)

COST IMPACT

3.1 $$

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Tile: Amtico International, Stratica (vinyl-free, chlorine-free resilient flooring)
Amtico International
6480 Roswell Road
Atlanta, GA 30328
404-267-1921

4.2 Resilient Flooring Adhesive: Foremost Products Co., Inc.
W.F. Taylor
11545 Pacific Avenue, Suite A
Fontana, CA 92337
909-360-9840

SECTION 09680 – CARPET

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Recycled content: minimum 50% total recycled content, with not less than 10% post consumer recycled materials and the balance post-industrial recycled materials.

B. Materials: all materials shall be high quality and of the type generally accepted for use in the industry. When used as intended, the materials shall be non-toxic, non-allergenic and free of similar health hazards. These materials include, but are not limited to, adhesives, cleaners, solvents, etc.

C. Recyclability: The carpet must be 100% recyclable.

D. Carpet shall inhibit the growth of fungi, gram-positive and gram-negative bacteria, in accordance with AATCC 138 or AATCC 174, parts 2 and 3.

1.2 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specification, submittals, and/or test data) in terms of recycled content, and Indoor Air Quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.3 DELIVERY STORAGE AND HANDLING

A. Packaging: Refer to Division 1.

B. Provide temporary Ventilation as required by Division 1.

C. Mold and mildew prevention.

1.4 SITE CONDITIONS

A. Provide temporary ventilation as required by Section 01350.

B. Mold and mildew prevention.

1.5 SEQUENCING

A. Install high VOC–emitting materials before low VOC–emitting materials.

1.6 WARRANTY

A. Provide extended warranties for carpet, carpet tile, and adhesives.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Carpet, Carpet Tile and Adhesive:
1. Provide carpet products complying with the physical and performance requirements of article 1.1, System Description.
2. Provide releasable adhesive for carpet tile as recommended by carpet tile manufacturer and complying with the requirements of Section 01350. Adhesive must allow the removal of carpet tile at any time without damage to the carpet tile, backing or substrate.
3. Adhesives: materials must comply with the toxicity and emission limits specified above and with Section 01350.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning with HEPA vacuum as required by Section 01350.

B. Remove and recycle excess material as required by the Construction Waste Management Program, Section 01565.

END OF SECTION

NOTES

SECTION 09680 – CARPET – NOTES

JUSTIFICATION

1.1 Indoor Air Quality: Testing for TVOCs, IVOCs, and formaldehyde is recommended in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not adversely affect Indoor Air Quality.

1.2 Resource efficient materials (recycled content, recyclable, embodied energy, packaging, durability) reduce the need for virgin materials and reduce the use of landfill for post-consumer carpet material.

APPLICATION

2.1 Horizontal applications (flooring)

COST IMPACT

3.1 $

SECTION 09720 – WALL COVERING

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability.
2. Environmental issues certification: submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data for substrate, sizing, primer, adhesive, and wallcovering. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

PART 2 - PART 2 – PRODUCTS

2.1 MATERIALS

A. Polyethylene

1. Indoor air quality:
   a. Provide vinyl–free, chlorine–free, plasticizer-free wallcovering.
2. Recyclability:
   a. 100% without backing.

B. Fabric

1. Recycled content:
   a. Fabric wall covering panel fabrics using 100% post industrial recycled content polyester.
2. Recyclability:
   a. Provide fabrics that can be recycled.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 09720 – WALLCOVERING – NOTES

JUSTIFICATION:

1.1 Indoor Air Quality: Testing for TVOCs, IVOCs, and formaldehyde is recommended in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not adversely affect indoor air quality.

APPLICATION

2.1 Vertical surfacing (walls)

COST IMPACT

3.1 $

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Carnegie, Xorel
110 North Centre Avenue
Rockville Centre, NY 11570
800-727-6770
www.xorel.com
www.carhegiefabrics.com

4.2 Interface, Terratex Process by various fabric manufacturers including:
Guilford of Maine
Deepa

SECTION 09750 – STONE FACING

PART 1 - GENERAL

1.1 SUMMARY

A. Floor, walls (interior stone)

1.2 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:

B. Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content.

1.3 DELIVERY STORAGE AND HANDLING

A. Packaging:

1. Refer to Division 1.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide and fabricate stone from source:

1. Within a 500-mile radius of the project site.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 09750 – STONE FACING – NOTES

JUSTIFICATION

1.1 Specify locally quarried and locally fabricated stone.

1.2 Energy: Reduced transportation energy should result in cost savings.

1.3 Durability: Use of long-lasting material will avoid the need to replace it often. Stone is resource efficient because of its durability.

1.4 Recyclability (reuse or reclamation) of stone should be explored.

APPLICATION

2.1 Exterior cladding, flooring, paving, furniture, surfacing, paneling or other architectural features.

EXAMPLE PRODUCTS/MANUFACTURERS

3.1 Cold Spring Granite
www.coldspringgranite.com

SECTION 09910 – PAINTS

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:

B. Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. For assembly systems (e.g., floor and wall systems where the finish material is installed over a substrate, either with or without the use of adhesives), individual components of the system shall be tested separately. If all components meet the criteria established in Section 01350, no further testing shall be required. If one or more of the components of a system does not meet the criteria, the material may be tested again as an assembly. If this option to re-test is selected, then the specimen preparation must be constructed following manufacturer's recommended procedures for application of wet components and assembly of the system. If there is a difference between the manufacturer's recommended procedures and procedures required by the project specifications, request clarification from the Architect.

1.2 DELIVERY STORAGE AND HANDLING

A. Packaging:

1. Refer to Section 01350.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Indoor Air Quality

1. Provide low-or no-VOC paints and primer system.

B. Recycled Content

1. No recycled content paints and primers will be allowed on interior applications.
2. 80% recycled content total (minimum 10% post-consumer) paints and primers may be used at exterior locations only.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

SECTION 09910 – PAINTS – NOTES

JUSTIFICATION:

1.1 Indoor Air Quality: Testing for TVOCs, IVOCs, and formaldehyde is recommended in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not adversely affect Indoor Air Quality.

1.2 Resource efficient materials (recycled content, recyclability, embodied energy, packaging, durability) – Recycled content paints are available that reduce the need for new paint; however, the VOC emissions from recycled content paint should be carefully reviewed prior to use of such paints in indoor environments.

APPLICATION

2.1 Coating systems for various substrates including plywood, gypsum board, metal.

COST IMPACT

3.1 $

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Frazee
Envirokote
6625 Miramar Road
San Diego, CA 92121
619-276-9500

4.2 Glidden/ ICI Gliden
Spred 2000/Lifemaster 2000 (or revised product name)
925 Euclid
Cleveland, OH 44115
800-221-4100

4.3 AFM Safecoat
(800) 239-0321

SECTION 10270 – ACCESS FLOORING

PART 1 - GENERAL

1.1 RELATED WORK

A. See Carpet, Section 09680, and Resilient Flooring, Section 09650.

1.2 SYSTEM DESCRIPTION

A. Provide carpet tile and raised floor by a single manufacturer [option].

1.3 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content.

1.4 WARRANTY

A. Provide extended warranties.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Adhesive: provide adhesive for pedestals according to manufacturer's recommendations and in compliance with Section 01350 indoor air quality requirements and special adhesive requirements.

B. Cementitious filled formed panels: provide panels using 30% post-consumer recycled steel and 17%-30% fly ash in the cementitious fill mix.

C. Floor covering: Refer to carpet section.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 10270 – ACCESS FLOORING – NOTES

JUSTIFICATION

1.1 Energy Issues: Less energy required to heat air and to force air.

1.2 Cost: If raised floor functions as a plenum then deduct cost of ducting in ceiling.

1.3 Resource efficient materials (recycled content, recyclability, embodied energy, packaging, durability). Raised floors system's resource efficiency needs to be evaluated to determine to what extent/how the criteria are met.

1.4 Integration with carpet and resilient floor system; ease of operation and maintenance.

1.5 Indoor Air Quality: Testing for TVOCs, IVOCs, SOVOCs, MVOCs, and particulates is required in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not cause poor Indoor Air Quality.

1.6 Underfloor area should be treated as an underfloor air supply in terms of cleanliness.

APPLICATION

2.1 Raised floor is applied over structural slabs, pedestals supporting modular panels are fixed to substrate. Individual registers allow individual user to control air into space.

COST IMPACT

3.1 $$

3.2 None if raised floor replaces ceiling plenum space and ductwork.

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Interface Architectural Resources
Interface Access Flooring, Tec-Crete
5001 Birch Street
Newport Beach, CA 92660
949-263-8330
800-336-0225
www.interfacear.com

4.2 Tate
www.tateaccessfloors.com

SECTION 12484 – FLOOR MATS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. WORK INCLUDED: Furnish and install all recessed, stainless steel grid entrance mats and frames.

1.2 SUBMITTALS:

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content.

B. PRODUCT DATA: Submit manufacturer's published descriptive literature and complete specifications for products specified herein.

1.3 DELIVERY, STORAGE, AND HANDLING:

A. ENVIRONMENTAL REQUIREMENTS: Comply with the packaging, delivery, storage, and handling requirements of Section 01350.

B. STORAGE AND PROTECTION: Store mats and frames under cover, in a dry, protected, area until ready for installation.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 CLEANING:

A. CONSTRUCTION CLEANING: Remove scraps, packaging material, and other debris from the Project site. Leave mats in clean condition.

B. Remove and recycle excess material as required by the construction waste management program, Section 01350.

C. Final cleaning shall be as described in Section 01350.

END OF SECTION

SECTION 12484 – FLOOR MATS AND FRAMES – NOTES

JUSTIFICATION

1.1 Indoor Air Quality—Indoor air quality is improved by the use of metal walk off mats. Bacteria and other contaminants are removed to a certain degree from the shoes of people entering the building.

1.2 Mats are best located inside of all exterior doors and should be large enough to be usable (to catch both feet).

APPLICATION

COST IMPACT $

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Kadee

4.2 Arden Architectural

SECTION 12490 – WINDOW SHADES

PART 1 - GENERAL

1.1 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:

B. Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, and product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the site waste management program, Section 01565.

END OF SECTION

NOTES

SECTION 12490 – WINDOW SHADES – NOTES

JUSTIFICATION

1.1 Enhance daylight control design through blinds

1.2 Shades for glare control around computer monitors

1.3 Energy: Cost and use savings are reaped

APPLICATION

2.1 Apply shades at window

COST IMPACT

EXAMPLE PRODUCTS/MANUFACTURERS

SECTION 12500 – FURNITURE

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. RECYCLED CONTENT:

1. SABRC (State Agency Buy Recycled Campaign) Standards: Provide recycled content minimums for all steel derived products as described by CIWMB. (Refer to the following website for updated recycled content percentages: http://www.ciwmb.ca.gov/BuyRecycled/StateAgency)
2. Recycled content for MDF shall be as described in Section 6100, Section 06200, and Section 06400.

1.2 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. A four-day chamber test of the assembled system shall take place following a period of 10 day conditioning. Concentration calculations as described in Section 01350 must reflect the density of the furniture installation in the building. Refer to notes Section for more information.

1.3 DELIVERY STORAGE AND HANDLING

A. Precondition in a ventilated warehouse for ten (10) days prior to testing and subsequent delivery to job site. During conditioning period, controlled temperature and humidity shall be maintained and 1 ac/h of clean air must circulate freely around furniture components (assembly is not required).

PART 2 - PRODUCTS

2.1 MATERIALS

A. Certified sustainably harvested woods

B. No particle board

C. Use core board, composite wood products, and MDF as described in Division 7.

D. Low-VOC sealers and adhesives

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 12500 – FURNITURE – NOTES

JUSTIFICATION

1.1 Indoor Air Quality--Testing for TVOCs, IVOCs, SOVOCs, MVOCs, and particulates is required in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not cause poor Indoor Air Quality.

1.2 Resource efficient materials (recycled content, recyclable, embodied energy, packaging, durability) Furniture's resource efficiency needs to be evaluated to determine to what extent/how the criteria are met.

APPLICATION

COST IMPACT $

EXAMPLE PRODUCTS/MANUFACTURERS

SECTION 12510 – OFFICE SYSTEMS FURNITURE

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Recycled Content:

1. Recycled content for MDF shall be as described in Section 06100, Section 06200, and Section 06400.

1.2 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. A four-day chamber test of the assembled system shall take place following a period of 10 day conditioning. Concentration calculations as described in Section 01350 must reflect the density of the furniture installation in the building. Refer to notes section for more information.

1.3 DELIVERY STORAGE AND HANDLING

A. Precondition in a ventilated warehouse for ten (10) days prior to testing and subsequent delivery to job site. During conditioning period, controlled temperature and humidity shall be maintained and 1 ac/h of clean air must circulate freely around furniture components (assembly is not required).

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

N
O
T
E
S

SECTION 12510 – OFFICE SYSTEMS FURNITURE – NOTES

JUSTIFICATION

1.1 Ventilation at desk top allows individual control better Indoor Air Quality.

1.2 Indoor Air Quality--Testing for TVOCs, IVOCs, SOVOCs, MVOCs, and particulates is required in order to determine emissions levels. Emissions testing is an emulation of how a product will perform when installed. Testing is needed to establish that the product does not cause poor Indoor Air Quality.

1.3 Resource efficient materials (recycled content, recyclability, embodied energy, packaging, durability). Office systems furniture's resource efficiency needs to be evaluated to determine to what extent/how the criteria are met.

1.4 Reuse workstations to increase useful life and avoid frequent replacement, thus reducing impact on landfill.

1.5 Modular units will provide versatility and increase useful life.

1.6 Emissions testing with good results will improve indoor air quality.

APPLICATION

2.1 Open office furnishing systems

COST IMPACT

EXAMPLE PRODUCTS/MANUFACTURERS

4.1 Steelcase

4.2 Herman Miller

4.3 Knoll

4.4 Studio eg

SECTION 12520 – SEATING

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Recycled Content:

1. Recycled content for MDF shall be as described in Section 06100, Section 06200, and Section 06400.

1.2 SUBMITTALS

A. SPECIAL ENVIRONMENTAL REQUIREMENTS:
Submit the following in accordance with the requirements of Section 01350:

1. Resource efficient product data: Submit required information concerning project recyclability (packaging), product recycled content, product recyclability,
2. Environmental issues certification: Submit written certification stating that the products installed are essentially the same as those defined by the Project requirements (specifications, submittals, and/or test data) in terms of recycled content, recyclability and indoor air quality.
3. Indoor Air Quality: Submit Material Safety Data Sheets (MSDS) and emission test data. A four-day chamber test of the assembled system shall take place following a period of 10 day conditioning. Concentration calculations as described in Section 01350 must reflect the density of the furniture installation in the building. Refer to notes section for more information.

1.3 DELIVERY STORAGE AND HANDLING

A. Precondition in a ventilated warehouse for ten (10) days prior to testing and subsequent delivery to job site. During conditioning period, controlled temperature and humidity shall be maintained and 1 ac/h of clean air must circulate freely around furniture components (assembly is not required).

PART 2 - PRODUCTS

2.1 MATERIALS

A. Product shall emit no formaldehyde when tested per Section 01350.

PART 3 - EXECUTION

3.1 CLEANING

A. Final cleaning shall be as described in Section 01350.

B. Remove and recycle excess material as required by the construction waste management program, Section 01565.

END OF SECTION

CONTENTS

CONTENTS 1
DISCLAIMER 2
SECTION 15060 - HANGERS AND SUPPORTS 3
SECTION 15080 - INSULATION 4
SECTION 15110 - VALVES 15
SECTION 15120 - PIPING SPECIALTIES 16
SECTION 15130 - PUMPS 17
SECTION 15620 - WATER CHILLERS 19
SECTION 15640 - PACKAGED COOLING TOWERS 23
SECTION 15720 - AIR HANDLING UNITS 25
SECTION 15730 - UNITARY AIR CONDITIONING EQUIPMENT 26
SECTION 15760 - TERMINAL HEATING AND COOLING UNITS 31
SECTION 15810 - DUCTWORK 34
SECTION 15820 - DUCT ACCESSORIES 38
SECTION 15830 - FANS 41
SECTION 15840 - AIR TERMINAL UNITS 43
SECTION 15860 - AIR CLEANING DEVICES 45
SECTION 15970 - MECHANICAL COMMISSIONING 47
SECTION 15970 - MECHANICAL COMMISSIONING - NOTES 51
SECTION 15990 - TESTING, ADJUSTING, AND BALANCING 52

DISCLAIMER

The authors have tried to make the information in this document as accurate and useful as possible. However, they make no warranty, express or implied, and assume no legal liability for the information in this report. References to specific manufacturers or products are provided for the convenience of the reader and shall not be considered endorsements.

These specifications were prepared as a 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 warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

SECTION 15060 - HANGERS AND SUPPORTS

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Thermal Hanger Shields.
1. 360^{o} high density insert:
a. 100 psi waterproofed calcium silicate.
b. Same thickness as adjoining pipe insulation.
2. 360^{o} galvanized sheet metal shield.
a. Shield length and gauges:

Pipe Size	Shield Length	Minimum Gauge
1/2-1 1/2	4	26
2 - 6	6	20
8 - 10	9	16

3. Insert to extend one inch beyond metal shield ends on chilled water piping:
4. Use double layer shield on bearing surface for:
a. Roller hangers.
b. Support spacing exceeding 10 feet.
5. Similar to Pipe Shields Incorporated.

PART 3 - EXECUTION

3.1 PIPE HANGERS, SUPPORTS AND GUIDES

A. Horizontal insulated piping:
1. Install thermal hanger shields for all supports.
2. See Section 15080: INSULATION for insulation connection to shields.

B. Vertical insulated piping:
1. Install thermal hanger shields at guides.
2. See Section 15080: INSULATION for insulation connection to shields.

END OF SECTION

SECTION 15080 - INSULATION

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 GENERAL

A. Thickness: Where specified thickness exceeds available single thickness provide multiple layers with staggered joints.

2.2 MATERIALS

A. Pipe & Equipment Insulation:
   1. Fiber glass:
      a. Molded: one piece, maximum 0.26 K factor at 75 deg F mean temperature.
         i. Similar to Owens-Corning ASJ/SSL-II Pipe Insulation.
      b. Blanket: minimum 1 lb. density, maximum 0.28 K factor at 75 deg F mean temperature.
         i. Similar to Owens-Corning Unfaced Duct Wrap.
      c. Board: Density as noted, maximum 0.26 K factor at 75 deg F mean temperature.
         i. Similar Owens-Corning 700 Series.
         ii. Plain or faced as specified.
   2. Flexible, closed cell elastomeric thermal insulation:
      a. Molded pipe insulation:
         i. Maximum 0.27 K factor at 75 deg F mean temperature.
         ii. Maximum water vapor transmission rating of .17 perm-in.
      b. Sheet insulation:
         i. Maximum 0.28 K factor at 75 deg F mean temperature.
         ii. Maximum water vapor transmission rating of .17 perm-in.
      c. Similar to Armstrong "Armaflex".

B. Jackets and facings:
   1. Pipe insulation jackets:
      a. All-service or all-purpose:
         i. Laminate of white kraft facing.
         ii. Glass scrim reinforcing and aluminum foil.
      b. Weatherproof:
         i. Aluminum jacket:
            a) Moisture barrier adhered to inside face.
            b) Piping up to 4 inches: 0.016 inch thick.
            c) Piping larger than 4 inches: 0.020 inch thick.

d) Longitudinal seams on bottom.

ii. Secure to insulation with aluminum or stainless steel bands.

iii. For sealing joints, see PART 3 EXECUTION.

2. Equipment insulation facings:
   a. Foil-scrim-kraft laminate of aluminum foil facing, glass scrim reinforcing, kraft paper backing.

C. Preformed Pipe Fitting Covers:
1. Factory fabricated formed covers of polyvinyl chloride or aluminum.
2. Polyvinylchloride covers similar to Manville "Zeston."
3. Polyvinyl chlorite covers for grooved end piping similar to Proto Corp. "Losmoke".
4. Aluminum covers similar to General Aluminum Supply Corp. "GASCO".

D. Adhesives and coatings:
1. Similar to Foster product names and figure numbers as follows:
   a. Lagging adhesive: 30-04, UP Label.
   b. Vapor barrier coating: Tite-fit 30-35, UP Label.
   c. Vaporseal adhesive: Spark-fas 85-20 UP Label.
   d. Cellular glass bedding and sealing compound adhesive: Foamseal 30-45.
   e. Outdoor mastic: Monolar Mastic 60-38 UP Label.
   f. Asphalt mastic: C.I. Mastic 60-25.
   g. For elastomeric insulation: 520 contact adhesive.

E. Wire, banding and fastening devices:
1. Wire: minimum 16 gauge copper clad annealed steel wire.
2. Bands: 3/4 in. nominal width with wing seals, of minimum thickness as follows:
   a. Aluminum: 0.007 in. except where exposed to weather, 0.020\in.
   b. Galvanized steel: 0.005 in.
   c. Stainless steel: 0.010 in.
3. Staples: outward clinching type of corrosion resistant steel.

F. Mechanical Fasteners:
1. Mild steel, copper plated.
2. Similar to AGM Industries "Power Base" insulation pins.
3. Insulation washers:
   a. Galvanized steel.
   b. 1- 1/2 inch diameter
   c. Similar to AGM Industries SLW-1

G. Chilled water insulation vapor-sealed.

2.3 DUCT INSULATION

A. Duct Wrap With Vapor Barrier; Type DW-V:
1. Flexible fiberglass wrap. 3/4 lb. per cu. ft.
2. Installed conductance: 0.30 Btu/sq. ft./inch/degree F.

3. Thickness per Duct Insulation Application Schedule.
4. Factory applied jacket.
    a. Foil-scrim-kraft laminate.
        i. Aluminum foil facing.
        ii. Glass scrim reinforcing.
        iii. Kraft paper backing.
        iv. Mylas
    b. Maximum vapor permeance: 0.02 perms.
    c. One 2-inch flange.
5. Similar to Owens-Corning All Service Faced Duct-Wrap.

B. Duct Board Without Vapor Barrier; Type DB:
1. Rigid board, 3 lb. per cu. ft.
2. Installed conductance: 0.23 Btu/hr/sq. ft./inch/degree F.
3. Thickness per Duct Insulation Application Schedule.
4. Similar to Owens-Corning Type 703.

C. Duct Board With Vapor Barrier; Type DB-V:
1. Rigid board, 3 lb. per cu. ft.
2. Installed conductance: 0.23 Btu/hr/sq. ft./inch/degree F.
3. Thickness per Duct Insulation Application Schedule.
4. Factory applied jacket.
    a. Foil-scrim-kraft laminate.
        a) Aluminum foil facing.
        b) Glass scrim reinforcing.
        c) Kraft paper backing.
    b. Maximum vapor permeance: 0.02 perms.
    c. One 2-inch flange.

2.4 DUCT AND PLENUM LINING

A. Rectangular Duct Lining; Type AL:
1. Material.
    a. Thickness per Duct Installation Application Schedule.
    b. 1-1/2 lb. per cu. ft. unless shown on plans to be 3 lb. per cu. ft.
    c. Installed conductance: 0.25 Btu/hr/sq. ft./inch degree F.
2. Interior air-side surface
    a. NFPA-90A compliant coating on side facing air stream.
    b. Suitable for velocity up to 4000 f.p.m.
    c. Meet erosion test method described in UL publication No. 181.
    d. Durable and mechanically cleanable.
    e. EPA registered anti-microbial agent.
3. Similar to Certainteed Toughgard Duct Liner. Standard duct liner will not be accepted.

B. Round Duct Lining; Type RAL:
   1. Material.
      a. Thickness per Duct Installation Application Schedule.
      b. Installed conductance: 0.23 Btu/hr/sq. ft./inch degree F.
   2. Interior air-side surface
      a. NFPA-90A compliant coating on side facing air stream.
      b. Suitable for velocity up to 5000 f.p.m.
      c. Meet erosion test method described in UL publication No. 181.
      d. Durable and mechanically cleanable.
      e. EPA registered anti-microbial agent.
   3. Self-supporting, slide-in installation.
   4. Similar to <u>Schuller Permacote Spiracoustic.</u> <u>Standard duct liner will not be accepted</u>.

C. Plenum Lining; Type PL:
   1. Material:
      a. Rigid fiberglass board 3 lb./cu ft
      b. Thickness per Duct Installation Application Schedule.
   2. Interior air-side surface
      a. NFPA-90A compliant coating on side facing air stream.
      b. Suitable for velocity up to 4000 f.p.m.
      c. Meet erosion test method described in UL publication No. 181.
      d. Durable and mechanically cleanable.
   3. Similar to Certainteed Toughgard Duct Liner Board. Standard duct liner will not be accepted.

PART 3 - EXECUTION

3.1 PIPE & EQUIPMENT INSULATION SCHEDULE

A. Insulation Types:
   1. Type P-1:
      a. Molded fiberglass.
      b. All-service jacket.
      c. Vapor-sealed.
   2. Type P-2:
      a. Molded fiberglass.
      b. All-service jacket.
   3. Type P-3:
      a. Flexible elastomeric insulation.
   4. Type E-1:
      a. Fiberglass board.
      b. 3 lb./cu ft density.
      c. Foil-scrim-kraft facing.

d. Vapor-sealed.

5. Type E-2:
   a. Fiberglass board.
   b. 6 lb./cu ft density.
   c. Segmented or scored for curved surfaces.
6. Type E-3:
   a. Flexible cellular foam insulation.

B. Application Schedule:

Service	Type	Size	Thickness
Hot Water	P-2	All	1-½”
Chilled Water	P-1	All	1”
Hot Water Pumps	E-3	all	1”
Chilled Water Pumps	E-3	all	1”
Flanged Ends, Water Chillers	E-3		Match chiller insulation
Chilled water air separators	E-1 or E-3		1”
Hot water air separators	E-2 or E-3		1”

C. Non-insulated piping and equipment:
1. Pneumatic control air.
2. Cooling coil condensation drain except concealed horizontal portions (by plumber).
3. Condenser water and condenser water pumps.
4. Refrigerant liquid lines.
5. All expansion tanks.
6. Vent, overflow, drain and relief, except as noted otherwise.
7. Hot water control valves.

3.2 PIPE INSULATION APPLICATION

A. General:
1. Butt edges neatly.
2. Fill voids with insulating cement.
3. Longitudinal overlaps:
   a. 2 in. minimum.
   b. For exposed work: toward ceiling or wall.
   c. For weatherproof aluminum jackets: on side to shed water.
4. Circumferential overlaps on weatherproof aluminum jackets: 2 in. minimum.
5. Continuous insulation passing through sleeves or other openings.
6. Oversize insulation to accommodate heat tracing on piping.

B. Valves, fittings, flanges and accessory insulation:
1. Unless otherwise noted, insulate:
   a. Valves including bonnets.
   b. Flanges.

c. Fittings.
d. Strainers.
e. Expansion joints.
f. Specialties.

2. Insulation for strainers, expansion joints, fittings and accessories requiring servicing or inspection:
   a. Insulation removable and replaceable without damage.
   b. Enclosed within two piece, No. 18 gauge aluminum covers fastened with cadmium plated bolts and nuts.
3. Insulation of same thickness as adjacent piping insulation.
4. For piping systems insulated with fiber glass:
   a. Wire on pre-molded fiber glass fitting covers or mitered segments of pipe insulation.
   b. For pipe sizes under 3 in., hydraulic setting insulating cement may be used.
   c. Vapor barrier for vapor-sealed insulation only:
      i. Apply uniform layer of vapor barrier coating to cover entire surface of fitting insulation.
      ii. Embed layer of fiber glass tape into wet coating, extending 2 in. over adjoining pipe covering.
      iii. Apply finish layer of vapor barrier coating over entire surface.
   d. Finish for exposed locations only:
      i. Apply skim coat of insulating cement to smooth out surface of fitting insulation.
      ii. Embed layer of fiber glass tape into uniform coat of wet mastic, extending 2 in. over adjoining pipe covering.
      iii. Apply finish coat of same mastic over entire surface of fitting insulation.
5. For piping systems insulated with calcium silicate:
   a. Wire on pre-molded sections of calcium silicate fitting covers or mitered segments of pipe insulation.
   b. Under 3 in. pipe size, built up coating of insulating and finishing cement to match thickness of adjoining pipe insulation, may be used.
   c. For exposed locations only, apply skim coat of finishing cement to smooth out surface of fitting insulation.
6. Flanges: insulation sleeve of same material as pipe insulation, to cover flange and overlap insulation on adjacent piping.
   a. For calcium silicate insulation provide calcium silicate rings between sleeve and pipe insulation.
   b. Finish for outdoor locations only: weatherproof aluminum jacket compatible with weatherproof jacket on adjoining pipe insulation.

C. Thermal hanger shields at pipe hangers:
   1. 360^{o} high density insert:
      a. 100 psi waterproofed calcium silicate.

b. Same thickness as adjoining pipe insulation.

2. 360^o galvanized sheet metal shield.
   a. Shield length and gauges:

Pipe Size	Shield Length	Minimum Gauge
1/2-1 1/2	4	26
2 - 6	6	
8 - 10	9	16

3. Insert to extend one inch beyond metal shield ends on chilled water piping:
4. Use double layer shield on bearing surface for:
   a. Roller hangers.
   b. Support spacing exceeding 10 feet.
5. Similar to Pipe Shields Incorporated.
6. Butt insulation to shields.
7. Cold piping:
   a. Wet coat of vapor barrier lap cement on all butt joints.

D. Jackets and facings:
1. Vapor-sealed types: continuous; staples not permitted.
2. Adhere longitudinal laps.
   a. Adhere 3 in. wide joint strip, of same material as facing, at center of each butt joint.
3. Adhesives:
   a. Vapor-sealed insulation: vapor-seal adhesive.
   b. Heating service insulation: vapor-seal adhesive.
   c. Weatherproof aluminum jacket: sealing compound.
   d. Underground asphalt felt jacket: asphalt mastic.

E. Wiring, banding and fastening devices:
1. Secure insulation to piping and equipment in accordance with following minimum requirements:
   a. Piping insulation section 3 ft long:
      i. Concealed vapor-sealed insulation banded at ends and center.
      ii. Other concealed insulation banded at ends and center or stapled on 2 in. centers.
   b. Pipe fitting insulation:
      i. Loops of wire to secure mitered segments of insulation.
      ii. Wire spiraled on from end to end on blanket insulation.
   c. Outdoor piping weatherproof aluminum jackets banded at circumferential joints and center of each section.
      i. Lap joint at bottom.

3.3 EQUIPMENT INSULATION APPLICATION

A. General:

1. Apply insulation with edges tightly butted
   a. Joints staggered and secured in place by steel bands.
   b. Where necessary weld on suitable anchors.
2. Seal with 520 adhesive.
3. Special considerations:
   a. Chiller heads: removable and replaceable metal covers to allow tube removal.
   b. Provide sufficient clearance around openings for normal operation of equipment.

3.4 DUCT & PLENUM INSULATION SCHEDULE

A. Duct Insulation Type and Thickness Schedule:

Location	Cooling or Heat/Cool Supply	Heating-only Supply	Return
At SF discharge extent as shown on plans	2” 3# AL or 1.5” RAL	–	–
Outdoors	1.5” 1.5# AL or 1.5” RAL	1.5” 1.5# AL or 1.5” RAL	1.5” 1.5# AL or 1.5” RAL
Concealed between roof and insulated ceiling	1.5” DW-V	1.5” DW	–
In return air plenums	1.5” DW-V	1.5” DW	–
In unconditioned spaces	1.5” DW-V	1.5” DW	1.5” DW
Exposed within conditioned space	–	–	–
Lined duct on plans not labeled with thickness	1” 1.5# AL or 1” RAL	1” 1.5# AL or 1” RAL	1” 1.5# AL or 1” RAL
Terminal “cans”	0.5” 1.5# AL	0.5” 1.5# AL	0.5” 1.5# AL
Flex duct	By manuf.	By manuf.	By manuf.

B. Drywall Shaft, Floor, Roof and Plenum Insulation.
   1. By general contractor/insulation contractor

3.5 NON-INSULATED DUCTWORK

A. No insulation required:
   1. For ducts as indicated in Duct Insulation Type and Thickness Schedule, plus:
   2. Exhaust ducts.
   3. Return air transfer ducts, unless shown to be lined.
   4. Outdoor air ducts.

B. Do not line ducts:
   1. Where prohibited by codes.
   2. Food service exhaust.
   3. Dishwasher exhaust.
   4. Shower exhaust.

5. Ten feet downstream from humidifiers.

3.6 DUCT INSULATION INSTALLATION

A. General

1. Ensure that insulation is continuous through inside walls.
   a. See 15210 - Vibration Isolation for packing openings through walls.
2. Finish insulation neatly at hangers, supports and other protrusions.
3. Locate insulation joints or cover seams in least visible locations.
4. Where ducts run in groups too close to be individually insulated and finished:
   a. Completely fill all spaces between ducts with rigid or flexible insulating material.
   b. Insulate and finish exterior surfaces of group as specified for particular service.
5. Where ducts cannot be insulated after erection, insulate prior to installation.
6. Where specified thickness of insulation and/or lining exceeds available thickness in single layer, provide insulation and/or lining in 2 or more layers with joints staggered.
7. Preparation:
   a. Do not install covering before ductwork and equipment has been tested and approved.
   b. Ensure surface is clean and dry prior to installation.
   c. Ensure insulation is dry before and during application.
8. Mechanical fasteners:
   a. Adhered anchors:
   b. Clip off pin penetrations flush with insulation surface or facing.
   c. Seal pins and washers where pins penetrate vapor barriers.
      i. With 4 inch square pieces of vapor barrier material to match facing.
      ii. Adhere with vaporseal adhesive.
   d. Spacing on rectangular ducts:
      i. Typical of horizontal and vertical, unless otherwise specified.
      ii. Duct board:
         a) 3 inches in from edges.
         b) Intermediate fasteners: 1/2 inches on counter maximum spacing all directions.
         c) Not less than one pin per surface.
      iii. Duct wrap:

Side Dimension	Maximum Spacing
24 inches and under	None required
25 to 32 inches	Horizontal - none. Vertical: 1 row centered, 12 inches OC
33 to 48 inches	2 rows, 12 inches on center.
49 to 60 inches	3 rows, 12 inches on center.
61 inches and over	16 inches on center, all directions

iv. Duct wrap spacing applicable to flat surfaces of flat oval ducts.

9. Provide 24 gauge sheet metal Z section frames over edges of duct and plenum lining:
   a. At access openings and doors.
   b. Along edges exposed to air flow.

B. Rectangular Duct Wrap:
1. Without vapor barrier:
   a. Comply with published recommendations of manufacturer and with following:
   b. Secure with 4 inch strips of adhesive, 8 inches on center.
   c. For rectangular ducts 24 inches and wider, secure to bottom of duct with mechanical fasteners 18 inches on center.
   d. Wrap with 18 gauge galvanized wire, 18 inches on center.
2. With Vapor Barrier:
   a. Vapor barrier and sealing continuous without breaks. Vapor proof seal around supports and bracing.
   b. 2 inches lap strip at one end.
   c. Peel insulation for 2 inch lap strip along longitudinal joints.
   d. Seal lap strips with vaporseal adhesive. Similar to Foster's 85-15.

C. Round Duct Wrap:
1. General:
   a. Adhere flexible insulation to ductwork with adhesive applied in 6 inch wide strips on 16 inch centers.
   b. Provide 16 gauge annealed tie wire tied, spiral wound or half hitched at 16 inch centers.
   c. Butt insulation and seal joints and breaks with 2 inch lap of foil adhered over joint.
2. Apply duct wrap with vapor barrier as specified above for rectangular ducts.

D. Duct Board:
1. Comply with published recommendations of manufacturer and with following:
   a. Secure with 4 inch strips of adhesive, 8 inch on center.
   b. Secure on top, sides and bottom of duct with mechanical fasteners, spacing as scheduled.

E. Rectangular Duct Lining
1. Comply with SMACNA Duct Liner Application Standard, published recommendations of manufacturer, and following:
2. Apply adhesive over 100 percent of surfaces to be lined.
3. Surface adjacent to air flow, including at joints, to be uniformly flat.
4. Seal butt joints and exposed edges of liner to prevent erosion.
5. Mechanical fasteners:
   a. Spacing per SMACNA Duct Liner Application Standard.

F. Plenum Lining:
1. Comply with SMACNA Duct Liner Application Standards, published

recommendations of manufacturer, and following.

2. Apply adhesive over 100 percent of surface to be lined.
3. Install mechanical fasteners as follows:
   a. 18 inches on center, both ways, except where SMACNA Standard requires closer spacing.
   b. Within 2 inches of all edges.
   c. Clip-off pins after washers installed.

3.7 FIELD QUALITY CONTROL

A. Repair separation of joints or cracking of insulation due to thermal movement or poor workmanship.

END OF SECTION

SECTION 15110 - VALVES

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

A. Provide valves at full line size unless required for balancing or control functions.

B. Globe valves are not allowed except in control applications.

2.2 BUTTERFLY VALVES

A. Operator:
   1. Infinite throttling handle with memory stop when used for balancing: smaller than 8 inches.
   2. Gear operators: 8 inches and larger.

B. Factory tested bubble-tight at 150 psi.

2.3 BALL VALVES

A. 2 inches and smaller:
   1. Full port valves
   2. Bronze.
   3. Teflon seat ring.

2.4 CHECK VALVES

A. Check Valves, General Service:
   1. 2 inches and smaller:
      a. Swing check.
   2. 2-1/2 inches and larger:
      a. Swing Check.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide valves line size unless otherwise indicated.

B. Install valves with cast directional arrows in direction of flow.

C. Install swing checks in horizontal position.

3.2 VALVE APPLICATIONS

A. Butterfly valves: Use in 2-1/2” and larger piping.

B. Ball valves: Use in 2 inches and smaller piping.

C. Do not use gate, plug, or globe valves in any location.

END OF SECTION

SECTION 15120 - PIPING SPECIALTIES

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 STRAINERS:

A. Use where shown on plans at inlets to control valves.

2.2 PUMP SUCTION DIFFUSER

A. Use at pumps where straight pipe connection is not practical.

2.3 BALANCING VALVES

A. Select low pressure drop balancing valves.

2.4 TRIPLE DUTY VALVES

A. Do not use triple duty valves. Instead, provide low pressure drop, separate devices as required for the desired functions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install items in accordance with manufacturer's instructions.

3.2 STRAINERS AND SUCTION DIFFUSERS:

A. Install only where shown on plans before pumps and control valves.

B. Install ball valve with hose-end fitting for blow-off.

C. Install inside pump or valve isolation valves to facilitate servicing.

3.3 BALANCING VALVES

A. Location:
1. Use at all terminal coils with three way control valves unless dedicated pumps with VFD’s are provided.
2. Install in bypass around all coils with three way control valves.
3. Do not use on two way control valve systems or pumped coil systems.

3.4 TRIPLE DUTY VALVES

A. Shall not be used.

3.5 PIPING SPECIALTIES:

A. Locate thermometers and gauges in locations as shown on plans at elevations that are readable by personnel standing on floor.

B. Provide straight runs of piping upstream and downstream from flow meters as recommended by manufacturer. No exceptions.

END OF SECTION

SECTION 15130 - PUMPS

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 GENERAL:

A. Selection:

{*The* designer should check that this section of the specification does not conflict with the design in the plans. The designer should consider using this selection criteria in place of another less efficient.}

1. Pumps shall be selected with efficiency as the primary selection criteria.
   a. If selecting a larger size pump of the same manufacturer and type increases the overall pump efficiency by 3% or more, the larger size pump must be used.

B. Pump characteristics:

1. Operation at or near peak efficiency.
2. Impeller diameter:

{The designer should check that this section of the specification does not conflict with the design in the plans. The designer should check the pump curves for the maximum efficiency point.}

   a. For VFD driven pumps, trim impeller to maximum efficiency point on system curve at or above design point but not above 90 percent diameter point. Typically this will occur at the 90 percent of maximum volute diameter point or the maximum diameter impeller offered in that size volute.
   b. Motors on VFD driven pumps shall be selected for the design point and shall not be oversized to accommodate a larger than required impeller.
   c. The VFD shall include a load limiting feature to prevent overloading the motor.

C. Brake horsepower ratings:

1. Maximum 5 percent above those noted in schedules.

D. Motors:

1. All motors with nominal horsepower in excess of ½ hp shall be premium efficiency.

E. Pressure taps on both inlet and outlet for gauge connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The use of triple duty valves is not allowed, these valves typically have very high pressure drops which inflate the required pump head unnecessarily.

B. Allow at least 5 pipe diameters between pump suction entry and closest elbow, unless a pump suction diffuser is installed. Suction diffusers shall not be used in condenser water pumps drawing from an open cooling tower or where NPSHA may be a problem.

3.2 PRE-OPERATING CHECKS

A. Before operating pumps:

1. During installation assure that piping is clear of debris which might clog pump or strainers.
2. Check for sufficient lubrication.
3. Check for correct operation of check valve.
4. Check for correct rotation.
5. Assure that strainer is clean before commencing testing.
6. Ensure that coupling guards are installed on the couplings.

3.3 TESTING AND ADJUSTING

A. After starting pumps:

1. Check shut-off head to ensure impellers are properly trimmed

END OF SECTION

SECTION 15620 - WATER CHILLERS

PART 1 - GENERAL

1.1 INSTRUCTIONS TO BIDDERS

A. Chillers shown on plans were selected based on a detailed analysis of multiple chiller options provided by all four major chiller vendors. Chillers were selected based on a life cycle cost analysis over a 7.5 year study period. The analysis included the impact of chiller efficiency at both design and off-design conditions, variations in tower water entering temperature, and pressure drop across both evaporator and condenser as a function of flow rate. The building and chiller plant were simulated using a DOE-2 computer model.

{The designer must, under this approach, preselect the chillers to be used for the project through a detailed energy and cost effectiveness analysis. This typically requires DOE-2 modeling of the entire facility and chilled water plant with various chiller options. Firm pricing of the chiller options and efficiency performance data will need to be obtained from the chiller manufacturers. This type of modeling and analysis may be funded, either fully or in part, by the local electric utility (such as under PG&E Savings by Design) in some areas. The analysis may be performed before the project is put out to bid or after the contractor is selected with the assistance of the contractor.}

B. Because chiller energy performance is a function of many variables and cannot be easily specified, substitution and selection based on low price is not possible. Therefore, <u>chillers shown on plans shall be the basis of the contractor's bid.</u> Alternate chiller selections may be considered, but only after contractor selection and additional analysis is performed. No exceptions.

PART 2 - PRODUCTS

2.1 GENERAL

A. The unit shall be completely factory packaged including evaporator, condenser, compressor, motor, starter, lubrication system, control system, and all interconnecting unit piping and wiring. Any field installation if required, other than piping and normal control and power wiring, shall be clearly identified with the bid or shall be included in the vendors pricing.

B. Performance shall be certified in accordance with ARI Standard 550-92.

2.2 COMPRESSOR

A. Screw and/or centrifugal.

B. Single or multiple compressor. Multiple compressor chillers need not have separate refrigerant circuits. (Redundancy is provided by multiple chillers.)

C. Acceptable refrigerants: R-134a is the desired refrigerant. R-123 and R-22 are also acceptable for screw chillers but R-134a is preferred.

2.3 CONDENSER AND EVAPORATOR

A. Tubes may be high-efficiency, internally enhanced surface type. Each tube shall be roller expanded into the tube sheets and be individually replaceable.

B. Include refrigerant pump-out/reclaim connections.

C. Cleanable shell and tube type.

2.4 AIR-COOLED CONDENSER

A. 3/8” tubes bonded to plate-type fins with black epoxy coating.

B. Propeller fans with separate compartments for backflow prevention.

2.5 PURGE SYSTEM (R-123)

A. “Near Zero” high efficiency, air-cooled, able to operate independently from chiller.

B. Unit shall have lights to indicate running, fault indication, and service-needed; and an elapsed time meter.

2.6 FACTORY INSULATION

A. Insulation shall be fully factory installed.
   1. Insulation shall include entire evaporator barrel and heads.

B. Minimum 3/4 in. thick closed cell foam insulation (e.g. Armaflex II).

2.7 CONTROLS

A. Each unit shall be furnished complete with a digital control system in a lockable enclosure, factory mounted, wired, and tested. The control center shall include a minimum 40 character alphanumeric display showing all system parameters in the English language with numeric data in English units.

B. Digital programming of essential setpoints through a color coded, tactile-feel keypad shall include: leaving chilled water temperature; percent current limit; pull-down demand limiting; and remote reset temperature range.

C. System operating information shall include: return/leaving chilled water temperatures; return/leaving condenser water temperatures; evaporator/condenser refrigerant pressures; differential oil pressure; percent motor current; evaporator/condenser saturation temperatures; compressor discharge temperature; oil temperature; operating hours; and number of compressor starts.

D. Security access shall be provided to prevent unauthorized changing of setpoints, and to select local or remote control of the chiller, and to allow manual operation of the pre-rotation vanes and oil pump.

E. Interface with a building automation system:
   1. Air-cooled chillers:
      a. remote chiller start/stop
      b. reset of chilled water temperature
      c. demand limit
      d. chiller fault (shut down on a safety requiring reset).
   2. Water cooled chillers: Provide a gateway between the DDC control system and chiller control panels. Coordinate with Controls Subcontractor to map across all chiller control points listed above plus all alarm points and refrigerant temperature points to the DDC system.

2.8 COMPRESSOR-MOTOR STARTER

2.9 SHIPMENT

A. The unit shall be completely assembled, with all main, auxiliary, and control piping installed, controls wired, leak tests completed, air runs tested, and fully charged with refrigerant or charged with dry nitrogen (2 to 3 psig).

1. If the unit is not charged with refrigerant, the oil charge and miscellaneous materials shall be packed separately. The refrigerant charge shall be shipped concurrently or separately in cylinders for field evacuation and charging of unit.

PART 3 - EXECUTION

3.1 FACTORY PERFORMANCE TESTING

A. The chiller manufacturer shall conduct a certified performance test in accordance with ARI 550-92 test procedures to be witnessed by a representative of the Buyer.

B. If variable speed drives are proposed, the factory tests and performance guarantees apply to the drive and chiller as a unit.

C. The chiller shall be tested at three operating points randomly chosen by the Buyer one week prior to the test. No tolerance (such as that normally allowed by ARI 550) on efficiencies or capacities will be accepted.

D. Chiller manufacturer shall repair or replace equipment, at no cost to the Buyer, until equipment is certified by ARI 550 test procedures to meet the performance indicated in the manufacturer’s proposal at each of the three operating points tested. Should failure of any test result in a delay exceeding 10 working days, the chiller manufacturer shall also pay liquidated damages in the amount of $1000 for each day the project is further delayed while the chiller is being repaired or replaced. Alternatively, provided the design capacity is no less than 95% of that specified, the manufacturer may pay a one time penalty of $3000 per kW difference between the sum of the tested performance and the sum of the manufacturer’s specified performance for all of the three operating conditions.

E. The costs of travel for the Owner’s representative for the initial test will be borne by the Owner. However, the chiller vendor shall pay all transportation costs and hotel costs (if required) associated with witnessing any required factory re-testing for one witness originating from the Owners area

{The designer should enter in the correct reference for the point of origin of the witness for the chiller performance tests for travel arrangements.}

3.2 INSTALLATION

A. The unit shall not be installed in such a way as to lead to any degradation of chiller performance, or restrictions in either the chilled water or condenser water circuits.

3.3 TESTS AND START-UP

A. Supervised: by unit manufacturer's representative:

1. Charging.
2. Start-up.
3. Field testing.

3.4 STARTUP AND OPERATOR TRAINING

A. A factory trained, field service representative shall supervise final leak testing, charging, and initial startup and conduct concurrent operator instruction. Operator training will consist of classroom instruction and field testing

B. Submit six (6) copies of operations and maintenance manuals. Manuals shall be bound with index and tabs and include the following:

1. Equipment submittals.
2. Equipment performance curves or capacity tables.
3. Operating and maintenance instruction sheets and parts list.
4. Design Data sheets.
5. Contact person for more information.

END OF SECTION

SECTION 15640 - PACKAGED COOLING TOWERS

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Performance Certification:
   1. Provide independent CTI certification of cooling tower capacity In accordance with CTI Certification Standard 201.
   2. Acceptable in lieu of above:
      a. Field test, at no cost to Owner, witnessed by Engineer and/or Owner's representative.
      b. Provide instrumentation required for test, such as non-intrusive (e.g. ultrasonic) flow meters and temperature sensors, all with accuracies equivalent to those required by CTI tests.
      c. Conduct test in accordance with CTI 201 and CTI Test Procedure No. 105.
      d. If tower fails capacity test, provide any and all costs to increase tower capacity without increasing fan power by more than 10% from rated power.
      e. Provide written report.

1.2 SUBMITTALS

A. Submittal shall include:
   1. Cooling tower including:
      a. Fan motor.
      b. Sound levels.
      c. Method of performance test.

PART 2 - PRODUCTS

2.1 GENERAL

A. Type:
   1. Counterflow or crossflow - vertical discharge.
   2. Axial flow fans.

B. Selection:

{The designer should, in typical projects where the cooling towers are preselected, use the first two criteria and leave the paragraphs 3 and 4 in the specifications. If contractors will be selecting cooling towers, such as in a design/build or design assist project, the first two selection criteria should be kept in the specifications.

   1. Select for maximum 8°F approach temperature at design conditions.
   2. Select towers to minimize fan specific brake horsepower (BHP/cfm).
   3. Select towers for approach temperature at design conditions that shall not exceed that included in schedules.
   4. Fan brake horsepower shall not exceed that scheduled by more than 3% at design conditions.

C. Fans.

1. Propeller type: fixed aluminum blades.
2. Hub: cast iron or aluminum.
3. Drive:
   a. Multi-grooved neoprene/polyester belt drive.

D. Motors:
1. All motors shall be premium efficiency
2. Capacity:
   a. Minimum horsepower as scheduled.
   b. Operate driven devices under all conditions without overload.
3. Enclosure: totally enclosed fan cooled

E. Capacity control:

{The Designer should verify that this section does not conflict with the drawings and equipment schedules.

1. Provide VFD’s for capacity control and energy efficient unloading of fans.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Complete piping connections per manufacturer's instructions and piping diagram.
1. Include equalizer with valve for isolation.

3.2 START-UP AND INSTRUCTION

A. Comply with manufacturer's instructions for filling and start-up operation including:
1. Verify lubrication of rotation parts:
   a. Lubricate as needed.
2. Verify fan rotation direction.
3. Verify that motor amperage is in accordance with manufacturer's data.
4. Balance condenser water flow to each inlet for multiple inlet towers.
5. Adjust water level control for proper operating level.
6. Make sure that all air is vented from the condenser. Air entrapped in the condenser has an adverse effect on chiller efficiency.

END OF SECTION

SECTION 15720 - AIR HANDLING UNITS

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 FANS

A. See Section 15830: FANS.

2.2 AIR HANDLERS

A. Cabinets:
   1. Insulated: minimum 1 in. thick, coated fiberglass board NFPA-90 approved, 1.5 lb. density.
   2. Internal static pressure drops shall not exceed those scheduled in the drawings by more than 5%. This includes coils, filters, cabinet losses, and outdoor air intakes.

{ The designer should select the units to minimize internal pressure drops within reasonable limits. For example, velocities at outdoor air intakes and hoods should be kept low to avoid intake pressure drops in excess of 0.2" w.g.}

B. Drain pans:
   1. Insulation: minimum 1 in. thick, coated fiberglass board NFPA-90 approved, 1.5 lb. density.
      a. Intermediate drain pans need not be insulated.

C. Filter section.
   1. See Section 15860: AIR CLEANING DEVICES.
   2. Prefilters should not be used after construction is completed.
   3. Filter gauges:
      a. Clogged filter signal on control panel.

2.3 MOTORS

A. All motors with nominal horsepower in excess of ½ hp shall be premium efficiency.

PART 3 - EXECUTION

3.1 TESTING AND ADJUSTING

A. Start-up and adjust completed air handling units to insure proper operation.

B. Provide operational tests to demonstrate proper operation and adequate capacity at completion of balancing and adjusting.

C. Supply and install sheaves as necessary for final air balancing.

D. Check the operation of the economizer.

END OF SECTION

SECTION 15730 - UNITARY AIR CONDITIONING EQUIPMENT

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 2.01 PRODUCT INFORMATION

A. All unitary equipment shall be fully factory packaged, tested and performance rated as a unit.

B. Minimum efficiency of Unitary Air Conditioners and Condensing Units. All packaged units shall have a minimum ARI rated efficiency meeting or exceeding the Minimum Required Efficiency listed below. Minimum Title 24 efficiency levels are listed for comparison. (Note: The efficiency levels from the 2001 standards are listed here. Check www.energy.ca.gov/efficiency/ for future updates)

	Title 24 (for comparison only)	Minimum Required Efficiency
Air Cooled < 65,000 Btuh	10 SEER	12 SEER
Air Cooled 65,000 – 135,000 Btuh	10.3 EER	10.3 EER
Air Cooled 135,000 – 240,000 Btuh	9.7 EER	9.7 EER
Air Cooled > 240,000 Btuh	9.5 EER (8.2 if >760KBtu)	10.0 EER
Water Cooled* < 65,000 Btuh	9.3 EER	12.0 EER
Water Cooled* 65,000 – 135,000 Btuh	11.5 EER	13.0 EER
Water Cooled* > 135,000 Btuh	11.0 EER	11.0 EER
Condensing units, water or evaporative cooled	13.1 EER	13 EER
* Includes Evaporative Condenser and Evaporative Pre-Cooled Condenser		

C. Minimum efficiency of Heat Pumps. All packaged heat pumps shall have a minimum ARI rated efficiency meeting or exceeding the Minimum Required Efficiency listed below. Minimum Title 24 efficiency levels are listed for comparison. (Note: The efficiency levels from the 2001 standards are listed here. Check www.energy.ca.gov/efficiency/ for future updates).

	Title 24 (for comparison only)	Minimum Required Efficiency
Air Source < 65,000 Btuh	10.0 SEER, 6.8 HSPF	12.0 SEER, 7.6 HSPF
Air Source 65,000 – 135,000 Btuh	10.1 EER, 3.2 COP	10.1 EER, 3.2 COP
Air Source >135,000 Btuh	9.3 EER, 3.1 COP	9.3 EER, 3.1 COP
Water Source < 135,000 Btuh	12.0 EER, 4.2 COP	13.0 EER, 4.5 COP

D. Economizers.

1. Economizers shall be provided when required by Title 24. [Note to designer: For units smaller than the Title 24 threshold, economizers are not recommended since they tend to be unreliable and small units are not typically well maintained. They are also not usually integrated with mechanical cooling which limits their effectiveness.]

2. Economizer high-limit switch shall be one of the following:
   a. Outdoor air dry-bulb thermostat set to disable the economizer when outdoor air temperature is greater than 75°F.
   b. Differential dry-bulb controller set to disable the economizer when outdoor air temperature exceeds return air temperature.
3. Fixed or differential enthalpy controls shall not be allowed. [Note to designer: Differential enthalpy switches are theoretically the most efficient but offer little savings in California climates and are difficult to calibrate and maintain. Fixed enthalpy switches should not be used in California climates.]
4. Economizers shall be fully integrated with mechanical cooling: The economizer shall continue to introduce 100% outdoor air (until disabled by the high-limit switch) even when mechanical cooling is required to supplement the economizer to meet the load.

E. Ventilation Outdoor Air Control
1. Minimum ventilation outdoor air control.
   a. Variable air volume systems shall have a positive means to maintain minimum outdoor air rates regardless of supply air volume. Setting a fixed minimum outdoor air damper position shall not be acceptable. Acceptable means include:
      i. Separate minimum damper setpoints for design supply air volume and minimum supply air volume, as indicated by fan speed or other supply air duct static pressure controller. [Note to designer: this is the least accurate method, but least expensive and available as standard on some packaged units.]
      ii. Outdoor airflow measuring station designed to be ±10% accurate at minimum airflow rates, used to modulate outdoor air and/or return air dampers to maintain minimum outdoor air flow rates.
      iii. Differential pressure sensor across fixed minimum outdoor air damper with setpoint calibrated to correspond to minimum outdoor air rate, used to modulate return air dampers to maintain minimum outdoor airflow rates.
   b. Systems with design outside air capacities greater than 3000 cfm serving densely occupied areas having an average design occupancy density exceeding 100 people per 1000 ft^2 shall include means to automatically reduce outside air intake during when spaces are not fully occupied. This shall be done using carbon dioxide (CO_2) sensors located in the spaces served. Controller shall modulate outdoor air intake from design rate down to no lower than 0.15 cfm/ft^2 as required to maintain space CO_2 concentration at setpoint. Setpoint shall be based on accepted engineering analysis or the following equation:

$$C_R = \frac{10500}{V_P} + C_{OA}$$

where C_R is the room CO_2 concentration (ppm), C_{OA} is the outdoor air CO_2

concentration (ppm), and V_P is the design outdoor air rate per person (cfm/p). If the outdoor air CO_2 concentration is not measured, 350 ppm may be assumed in the equation above.

2. Variable air volume unit controls:
   a. Variable speed drives shall be provided for controlling the following variable air volume fans:
      i. Supply fans greater than 5 HP.
      ii. Return fans, whenever drives are provided on supply air fans.
      iii. Relief/exhaust fans greater than 7.5 HP.
   b. Supply fan static pressure control:
      i. The static pressure sensor for supply air fan control shall be located down the duct system such that its setpoint may be set to no higher than 1/3 of the fan design total static pressure. Locating the sensor directly at the fan discharge shall not be acceptable.
      ii. For systems with direct digital control of variable air volume boxes, static pressure setpoint shall be reset to maintain at least one VAV box damper near wide-open. This requires that VAV box controllers have feedback or other means to determine VAV box damper position and the ability to monitor the position of all VAV boxes and convey this information to the static pressure setpoint reset controller.

F. Required Monitoring Points (in addition to control points required elsewhere in the specification) for systems with buildings automation system or similar interface.

IF unit meets this criteria	THEN this is required
Variable Speed Fan	Fan kW
Greater than 10 tons	Total kW
Greater than 5 tons	Outside air temperature, supply air temperature, return air temperature, mixed air temperature
Greater than 50 tons	Return air damper position, Outside air dampers position (min. damper and economizing damper)
VAV system	Duct static pressure

PART 3 - EXECUTION

3.1 COMMISSIONING

A. Commissioning Agent. If not otherwise designated, the commissioning agent shall be the design engineer-of-record.

B. Pre-Start Inspection

1. After equipment has been submitted and approved, the commissioning agent shall prepare the Pre-Start Test forms herein by filling in all of the “as-designed” data from submittals. A form shall be completed for every piece of equipment for which there is a form; all such equipment will be inspected as part of this phase, not just a representative sample. (Note: for some packaged equipment

composed of multiple devices, two or more forms may have to be completed.) Completing the forms is best done near the end of construction after any revised or resubmitted products have been approved. (Note: The submitted and approved materials and equipment may differ from those specified on plans and in specifications; it is the design engineer's, rather than the commissioning agent's, responsibility to ensure that the approved products are "equal" to the specified products.)

2. The HVAC contractor shall develop a Pre-Start test schedule based on the construction schedule and the degree of completion indicated on the forms. This shall be reviewed and approved by the commissioning agent. (The best time to complete the tests is after construction but before systems have been started and balanced. The successful completion of the tests will help ensure that systems are in fact ready to be started and balanced.)
3. The commissioning agent, in the presence of a representative from the HVAC contractor, shall complete the "as-found" column of each of the forms as equipment is inspected per the Pre-Start Test schedule. If there is a discrepancy between the specified/submitted material or equipment and that found, if the workmanship is found to be defective, or if work is found to be incomplete, the required corrective action shall be noted on the form. The commissioning agent shall sign each form when it has been completed.
4. Each form that indicates a need for corrective action shall be copied to the HVAC contractor or other responsible party. The contractor will then notify the commissioning agent when all corrective work has been completed. The commissioning agent will subsequently re-inspect the equipment and initial the column marked "Done" if work was successfully completed. The commissioning agent shall again sign the form when all corrective work indicated on the form is complete.
5. If corrective action is still incomplete after step 4, repeat step 4 as required.

C. Functional Tests

1. For each set of functional test conditions, record the values of all the operating parameters and compare to acceptable values/ranges provided in advance by the design engineer.
2. Peak Cooling Load
   a. Set all cooling setpoints to min (e.g. 60F) to force max cooling load
3. No Cooling Load
   a. Set cooling setpoints to max (e.g. 85F) to force no cooling load
4. Min OA at Peak Cooling Load
   a. Override the OA temp reading. Set OA temp > RA temp. Set OA temp > 55 ^{O}F for an integrated economizer.
   b. Set cooling setpoint to min (e.g. 60F) to force max cooling load
5. 100% OA at Peak Cooling Load
   a. Override the OA temp reading. Set OA temp < RA temp
   b. Set cooling setpoint to min (e.g. 60F) to force max cooling load
6. Min OA at Min Cooling Load
   a. Override the OA temp reading. Set OA temp > RA temp
   b. Set cooling setpoint to max (e.g. 85F) to force no cooling load

7. Min OA at Intermediate Cooling Load
   a. Override the OA temp reading. Set OA temp > RA temp
   b. Set half cooling setpoints to min and half to max. For single zone systems
8. Night Setback (if applicable)
9. Night Setback + User Override (if applicable)
10. CO_2 sensor Sequences (if applicable)

D. Owner, design engineer, and other relevant parties shall be given at least one weeks notice of all functional tests in order to witness testing.

E. Functional testing shall not be performed until all other testing and start-up requirements are satisfied.
1. All functional tests shall be fully documented.
2. If any test results fall outside of the acceptable ranges the contractor shall make appropriate corrective action and re-perform the failed test. This process is repeated until an acceptable test result is achieved or a written explanation of failure is signed off by the design engineer, commissioning authority or other relevant party.
3. Sample test form:

Equipment tested:	AC-3		
Date:	7/6/01		
Participants:	John Doe, YXZ Mechanical Contractors; Jane Doe, ABC Controls;		
Test ID:	Functional Test #43		
Test Objective:	Verify that min OUTDOOR AIR CFM is maintained at peak supply flow		
Test Conditions:	OA temperature overridden and set to 80F. Cooling setpoint for all zones set to 60F		
Notes:			
Parameter	Expected Value	Acceptable Range	Observed Value
OUTDOOR AIR temperature		any	
Supply air temp	55	53-57	
Supply CFM	20,000	18,000 – 23,000	
Fan kW			
Compressor kW	35-45 kW (if 50 < OA < 60 F) 40-50 kW (if 60<OA<70 F) etc	35-45 kW (if 50 < OA < 60 F) 40-50 kW (if 60<OA<70 F) etc	
OA flow (CFM)	6,000	5,800 - 6,500	
OA damper position	min	Min	
Etc			

END OF SECTION

SECTION 15760 - TERMINAL HEATING AND COOLING UNITS

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 CHILLED WATER COOLING COILS

A. Extended surface type coils:
   1. Copper Tubes.
      a. Minimum thickness: 0.020 inch.
      b. Outside diameter 5/8 inch.
   2. Plate fins of copper or aluminum.
      a. Minimum thickness: 0.008.

B. Rows and fin spacing.
   1. To meet performance scheduled at similar or lower pressure drop.
   2. Selected with tube fouling factor of 0.001
   3. Maximum fins: 14 per inch.
   4. Select to avoid moisture carryover.

C. Face velocity and pressure drops.
   1. Coil airside pressure drop based on a wet coil shall not exceed 1.0” w.g. at design air flow conditions.
   2. Coil waterside pressure drop shall not exceed 15’ w.g. at design water flow.

D. Circuiting: full row.

E. Headers: Copper tubing or cast iron.

F. Certified by A.R.I. per current Standard 410.

G. Mount coil section in galvanized steel casing designed for bolting to other sections or ductwork.

H. Design for 200 psi, 220 degrees F.

I. Similar to Trane Type W.

2.2 MAIN HOT WATER HEATING COILS

A. Extended surface type coils:
   1. Copper Tubes.
      a. Minimum thickness: 0.020 inch.
      b. Outside diameter 5/8 inch.
   2. Plate fins of copper or aluminum.
      a. Minimum thickness: 0.008.

B. Rows and fin spacing.
   1. To meet performance scheduled at similar or lower pressure drop.
   2. Selected with tube fouling factor of 0.001

3. Maximum fins: 10 per inch.

C. Face velocity and pressure drops.
   1. Coil airside pressure drop shall not exceed 0.5” w.g. at design air flow conditions.
   2. Coil waterside pressure drop shall not exceed 6’ w.g. at design water flow.

D. Circuiting: full row.

E. Headers: Copper tubing or cast iron.

F. Certified by A.R.I. per current Standard 410.

G. Mount coil section in galvanized steel casing designed for bolting to other sections or ductwork.

H. Design for 200 psi, 220 degrees F.

I. Similar to Trane Type W.

2.3 ZONE TERMINAL HOT WATER REHEAT COILS

A. Tubes and fins.
   1. Copper Tubes.
      a. Minimum thickness: 0.020 inch.
      b. Outside diameter 1/2 inch or 5/8 inch.
   2. Aluminum fins.
      a. With full fin collars
      b. Minimum thickness: 0.008.

B. Rows and fin spacing.
   1. One or two row as required to meet performance scheduled at similar or lower pressure drop.
   2. Selected with tube fouling factor of 0.001
   3. Maximum fins: 10 per inch.

C. Face velocity and pressure drops.
   1. Coil airside pressure drop shall not exceed 0.3” w.g. at design air flow conditions.
   2. Coil waterside pressure drop shall not exceed 3’ w.g. at design water flow.

D. Circuiting: full row.

E. Connections
   1. Copper, external, same end.
   2. Male solder

F. Galvanized steel casing designed for connection to terminal and ductwork.
   1. Removable for easy service and replacement.
      a. Factory access panel for coil inspection and cleaning.
      b. Factory-tested at 150 psi under water.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Water connections:
  1. Supply at bottom of supply header.
  2. Return at top.
  3. Self-venting.
  4. Counterflow: air flow opposite to water flow.
  5. Manual air vents at high points.
  6. Drain connection at low points.

B. Protect coils so fins and flanges are not damaged.
  1. Replace loose and damaged fins.
  2. Comb out bent fins.

END OF SECTION

SECTION 15810 - DUCTWORK

PART 1 - GENERAL

1.1 SUBMITTALS

A. Indoor Air Quality Data: Refer to Section 01350, Special Environmental Requirements, Article 1.4.B, Indoor Air Quality Data, for required submittals of Material Safety Data Sheets (MSDS), emission test data for insulation, sealers.

B. Certificates: Provide Environmental Issues Certifications as described in Section 01350, Special Environmental Requirements, Article 1.3.C, certifying that the products installed are essentially the same as those defined by the project requirements (specifications, submittals and/or test data) in terms of indoor air quality requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 MATERIALS

A. Elbows:
1. Elbows in rectangular ducts shall have minimum inside radius equal to width in direction of turn.
2. Where full radius is not practical, elbows shall be mitered with turning vanes.

B. Turning vanes:
1. Galvanized steel ductwork: galvanized steel or painted black steel, except as noted.
2. Other ductwork: same material as ductwork.
3. Construction per SMACNA "HVAC Duct Construction Standards" for:
   a. Single wall vanes with 3/4 inch trailing edge.
   b. Double wall vanes: Not acceptable
   c. Vane length:
      i. Provide separate equal size sections for vane length greater than those indicated in referenced "Standards."
   d. Vane runners:
      i. Type 1 or 2 acceptable.
      ii. Submit any other type for approval
4. Vane radius:
   a. 2 inch radius: duct width up to 36 inches.
   b. 4-1/2 inch radius: duct with 36 inches or larger.

C. Low pressure round duct take-off fittings in rectangular duct:
1. Factory-fabricated conical tapered fitting.
2. Factory-fabricated 45 degree takeoff fittings.
3. Duct sized 90 degree fittings are not allowed at velocities exceeding 800 feet per

minute.

4. Extractors or “scoops” are not allowed in any application.

2.3 ROUND AND OVAL DUCTWORK

A. General:
1. Fittings:
a. Tees:
i. 45 degree conical tap.
ii. Center-line take-off, unless otherwise indicated.
b. Elbows:
i. Gores:
a) 2 gores - less than 35 degrees.
b) 3 gores - 36 degrees through 71 degrees.
c) 5 gores - over 71 degrees.

2.4 FLEXIBLE DUCTS

A. Flexible ducts:
a. Not allowed at equivalent smooth duct friction rates in excess of .08” per 100 feet.

PART 3 - EXECUTION

3.1 DUCT SYSTEM PRESSURE LOSS.

A. Maximum duct system static pressure loss for each duct system, general:

Application	Duct system pressure loss
Single zone systems less than 5000 CFM, total external	0.4” W.G.
Single zone systems between 5000 and 15,000, total external	0.6 w.g.”
VAV systems supply duct system	1.25” w.g.
VAV systems return duct system, plenum return	0.5” w.g.
Toilet exhaust system up to 3000 CFM	.5”
Toilet exhaust system greater than 3000 CFM	1”
Return air transfers	0.05”

3.2 DUCTWORK INSTALLATION

A. General:
1. Duct dimensions indicated are net, inside, clear, dimensions unless noted as “OD”.
2. Alter duct sizes on basis of equal friction where required to facilitate installation.
3. Tapers:
a. Pitch sides of duct in "diverging" or "converging" airflow maximum of 1 to 4 taper.
4. Volume dampers.

a. Install damper where specified in Section 15860: DUCT ACCESSORIES.

b. Install damper in every final branch only, unless indicated otherwise.

B. Elbows and Splits:

1. Use radius elbows in rectangular ducts unless otherwise indicated.
   a. Centerline radius not less than 1-1/2 times duct width.
2. Where space does not permit duct radius specified above, install short radius splitter vanes per referenced "Standards".
   a. Number of vanes determined by ratio of inner radius (R) to duct width in plane of radius (W).
      i. One vane: R/W above 0.3.
      ii. Two vanes: R/W between 0.1 to 0.3.
      iii. Three vanes: R/W 0.1 and smaller.
3. Use square turns in rectangular ductwork, unless indicated otherwise, at following locations:
   a. Use only where full radius elbow cannot fit.
   b. Use only in ducts with 2000 fpm or less design velocity. In 4" pressure class ducts, using multiple splitters instead of turning vanes.
4. In high and medium pressure ductwork spot weld turning vane to duct.

C. Joint Sealing:

1. Seal transverse and longitudinal joints of sheet metal ducts by one of following methods:
   a. Six ounce canvas strip, six inches wide. Adhere with lagging adhesive.
   b. Hardcast PS-S tape.
   c. United Hi-Velocity sealer.
   d. Gasketted TDC or Duct-Mate.

D. Seal punched holes and corner cracks.

E. After installation and testing reseal joints found to be leaking.

3.3 ROUND AND OVAL DUCTWORK

A. Joints between ducts:

1. Made with beaded sleeve joints as scheduled.
2. Duct sealer applied to male end.
3. Mechanically fastened with sheet metal screws or pop rivets.
4. Over joint and screw or rivet heads, apply coating of duct sealer.
5. Cover entire joint with duct tape.

B. Joints, duct and fitting:

1. Slip projecting collar of fittings into duct.
   a. Insertion length 2 inches minimum.
2. Apply duct sealer.
   a. Seal and tape as specified above.
3. Mechanically fasten.

a. Fastening schedule:

Diameter	End Lap	No. of Rivets in Slip Joint
8 in	3/4 in	4
9 to 16 in	1 in	6
17 in and larger	1-1/4 in	7

C. Junctions between ducts:

1. Branch take-off: 45 degrees or conical 90 degrees.

3.4 FLEXIBLE DUCTWORK

A. Installation:

1. Support adequately.
2. Minimum inside bending radius not less than one duct diameter.
3. Install as straight as possible.
4. Cut ducts to lengths required rather than create bends to take up excess lengths.

END OF SECTION

SECTION 15820 - DUCT ACCESSORIES

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 ACCESS DOORS

A. In ductwork:
   1. Insulated or uninsulated, same as duct.
   2. Size:
      a. 20 inches x 14 inches.
      b. Ducts less than 16 inches: one dimension 20 inches; other dimension 2 inch less than duct width.
      c. Larger sizes where required for access.
   3. Provide in following locations:
      a. Coils in ducts: entering and leaving side.
      b. Automatic dampers: linkage side.
      c. Smoke dampers.
      d. Fire dampers.
      e. Smoke detection heads.
      f. Filter banks.
      g. Fan bearings enclosed in ducts.
      h. Inlet side of each single width centrifugal fan.
      i. Inlet and outlet sides of each in-line centrifugal and axial fan.

2.2 DAMPERS

A. Volume Dampers:
   1. Provide at locations shown on plans.
      a. Provide also in wyes and spin-ins to outlets whether shown on plans or not, except.
         i. where dampers are not shown above inaccessible ceilings (system will be designed to be self-balancing with minor adjustments made at air outlets).
      b. Additional locations where dampers appear to be required for balancing, place request for information with Engineer prior to construction.
      c. No other locations without engineers written approval
   2. General:
      a. Single blade: less than 12 inches in blade width.
      b. Multiblade: 12 inches and wider blade width.
      c. Damper Hardware: Equal to indicated Ventlok model numbers for low pressure systems.
         i. For high pressure systems use Ventlok "HiVel" hardware, same model numbers.
      d. Actuating quadrants typical for single and multiblade dampers.

e. Conform to requirements of SMACNA HVAC Duct Construction Standards.
f. Bearing at one end of damper rod: No. 609.
g. Accessible quadrant at other end of damper rod:
   i. With lever and lockscrew: No. 635.
   ii. Insulated ducts:
      a) Quadrants mounted on collar to clear insulation.
      b) Nos. 637, 638, or 639.
      c) Selection based on insulation thickness.
h. For dampers above non-removable ceilings or without access panels provide No. 677 concealed damper regulator.
   i. With 2-5/8 inch paintable cover plate.
   ii. Required interconnecting hardware.

3. Single blade dampers:
   a. Galvanized steel ductwork: galvanized steel, except as noted.
   b. Blade: No. 18 gauge minimum.
   c. Other ductwork: as specified above, except same material as duct.
4. Multiblade Dampers:
   a. Low Pressure Systems:
      i. Opposed blade damper.
      ii. Up to 24 in. x 24 in. - Equal to Ruskin Model CD35
      iii. Larger than 24 inc. x 24 inc. - Equal to Ruskin Model CD35.
   b. High Pressure Systems:
      i. Rectangular:
         a) Opposed blade damper.
         b) Equal to Ruskin Model CD60.
      ii. Round and Oval:
         a) Oval - Equal to Ruskin Model CDR25 and DO25.
         b) Round - Up to 20 in. diameter - Equal to Ruskin Model MDRS25.
         c) Round - larger than 20 in. diameter - Equal to Ruskin Model CDRS25.

B. Backdraft Dampers:
   1. Required locations:
      a. Where shown on drawings.
      b. In suction or discharge of all exhaust fans as listed in equipment schedule.
   2. Construction:
      a. Extruded aluminum construction.
      b. Vinyl blade edge seals.
      c. Blade ends overlapping frame.

C. Fire Dampers:
   1. Multi-bladed, with blade housing out of air stream, equipped with fusible link:

a. In air stream style allowed when face velocity is less than 800 feet per minute.

2. Provide access door in duct adjacent to each fire damper.
3. Type

a. Rectangular type 1000 fpm and higher: Equal to Ruskin DIBD2 or DIBD10 Style B.

2.3 AUTOMATIC DAMPERS

A. Automatic Control Dampers. See 15900 CONTROLS & INSTRUMENTATION

B. Smoke Dampers:

1. Type

a. Similar to Ruskin Type SD60 for all locations with face velocities of 1800 fpm and above.

C. Combination Smoke and Fire Dampers:

1. Type

a. Similar to Ruskin Type SD60 for all locations with face velocities of 1800 fpm and above.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Install items in accordance with manufacturer's printed instruction.

END OF SECTION

SECTION 15830 - FANS

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 GENERAL

A. Wheel, factory balanced statically and dynamically.

B. Brake horsepower ratings:
   1. Maximum 5 percent above those noted.

C. Motors:
   1. All motors with nominal horsepower in excess of ½ hp shall be premium efficiency.

D. Belt drives.
   1. Matched, multiple V-belt.
   2. Capacity: minimum 1.5 times motor horsepower.
   3. Pulleys:
      a. Motor pulley:
         i. Variable pitch diameter:
            a) Except fans with variable frequency drives.
            b) Fans up to 7-1/2 hp motor.
            c) Fans from 10 hp to 25 hp, under 1000 rpm.
         ii. Fixed pitch diameter:
            a) Fans 10 hp and over 1000 rpm.
            b) Fans over 25 hp.
            c) Fans with variable frequency drives.
         iii. Select at mid-point of range.
      b. Supply and install one fixed pitch pulley change as required per fan to balance systems unless variable frequency drives are provided.
      c. Companion sheaves to maintain belts parallel.

2.2 CENTRIFUGAL FANS

A. Provide variable frequency drives (VFD) for all variable flow applications with fans of 5 HP and larger.

2.3 PROPELLER FANS

A. Provide variable frequency drives (VFD) or multiple staged fans with minimum 4 stages for all variable flow applications.

2.4 VANE AXIAL FANS

A. Provide adjustable pitch blades for all variable flow applications.

PART 3 - EXECUTION

3.1 FAN SELECTION

A. Select all fans with efficiency as the primary selection criteria. Typically this will result in a fan at least one or two sizes larger than the lowest cost selection.

{The designer should check that no part of this section conflicts with information on the plans and use this selection criteria for fan selections as well.}

1. The fan may be selected for a smaller unit if the fan efficiency, as determined by brake horsepower, does not decrease by more than 5% relative to the most efficient selection.

3.2 INSTALLATION

A. General.

1. Backdraft Dampers:
   a. Comply with CAC Title 24.
   b. Provide backdraft or shutoff dampers for suction or discharge of every exhaust fan as scheduled.
      i. Smoke damper(s) interlocked to fan may serve as backdraft device.

3.3 TESTING AND ADJUSTING

A. Start up and adjust fans to insure proper operation.

B. Provide operational tests to demonstrate proper operation and adequate capacity at completion of balancing and adjusting.

END OF SECTION

SECTION 15840 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUBMITTALS

A. Submittals shall include:
  1. Terminal units and air valves:
     a. Catalog cuts.
     b. Schedules:
        i. Each size and type with capacity performance.

PART 2 - PRODUCTS

2.1 TERMINAL UNITS

A. General:
  1. Casings:
     a. Leak rate: 7 cfm maximum leakage at 1.50 inch w.g.
     b. Gasketted flush-type access door:
        i. If actuators are mounted internally.
        ii. For access upstream of reheat coil
     c. Discharge duct connection.
  2. Control section complete with all actuators, sensors, pressure independent components furnished and mounted by unit manufacturer.
     a. Calibrated orifice with pressure taps.
     b. Multi-point, cross-flow, center averaging sensor.
        i. Amplify velocity pressure signals.
        ii. Provide accurate flow sensing regardless of inlet duct configuration.
  3. For Direct Digital Control, see Division 17 Energy Management and Control System.
  4. Moving parts suitable for minimum of 300,000 cycles.
  5. For hot water heating coils, see Section 15760: TERMINAL HEATING AND COOLING UNITS.

B. Variable Air Volume Terminal Units
  1. As specified above.
  2. Complete with hot water heating coil where indicated.
  3. Maximum design total pressure drop of 0.4” w.g. at design airflow without heating coils.
  4. Maximum design total pressure drop of 0.6” w.g. at design airflow with heating coils including coil.
  5. Equal to Titus Model ESV-3000II.

C. Fan Powered Terminal Units

1. As specified above, amended as follows.
2. Fan and motor:
    a. Forward curved, direct drive fan.
    b. Energy efficient motor.
3. Unit controls.
    a. As specified above.
    b. Adjustable SCR infinite fan speed control.
        i. With minimum voltage stop to insure motor cannot operate in stall mode.
        ii. Three-speed switches not acceptable.
4. Accessories:
    a. Access door required at heating coils for cleaning.
    b. Filter
        i. 1” filter frame.
        ii. Filter media required for units with heating coils.
        iii. Disposable filter cartridge.
        iv. 20% ASHRAE 52.2 DSE.
5. Style
    a. Series arrangement. Equal to Titus PTFQ
    b. Parallel arrangement. Equal to Titus PMFV
6. Units with hot water heating coil.
    a. For hot water heating coils, see Section 15760: TERMINAL HEATING AND COOLING UNITS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Terminal units:
  1. Supply duct connections: See Section 15050 for sizing criteria.
      a. Provide hard duct connections at inlet. No flex.

B. Coordinate access through ceilings with respective trades.

END OF SECTION

SECTION 15860 - AIR CLEANING DEVICES

PART 1 - GENERAL

PART 2 - PRODUCTS

2.1 MEDIA

A. All filters: UL Class 2

B. Type 1: Pleated Filter

1. 25%-30% dust spot efficiency
2. 2” or 4” pleated.
3. Cotton & synthetic media

C. Type 2: Bag Filter

1. 80%-85% dust spot efficiency
2. 30” deep
3. Synthetic media, two layers 100% polypropylene

2.2 FRAMES

A. For air handlers and fan-coils, see individual specifications.

B. Bag Filter Frames

1. 16 ga galvanized steel
2. Hardware and fasteners zinc plated.
3. Prefilter tracks
4. Closed cell foam gasket and woven pile barrier shall provide seal for installed filters.
5. Filter holding brackets
6. Front access.

PART 3 - EXECUTION

3.1 FILTER MEDIA

A. Media as selected in equipment schedules.

B. Construction filters: Type 1 for all equipment.

1. Construction filters to be removed after project completion.

3.2 INSTALLATION

A. Install frames per manufacturer's instructions.

3.3 START-UP PROCEDURES

A. Supply fans shall not be operated unless filters are installed, including temporary filters for use during construction.

B. If the final pressure drop of the temporary filters is reached during construction or test and balance, replace them with a spare set.

C. Remove temporary construction filters before air balancing and install clean final filters.
    1. Remove prefilters in front of bag filters after construction and <u>do not</u> replace. (Prefilters are not required for normal operation.)

END OF SECTIONSECTION 15970 - MECHANICAL COMMISSIONING

PART 1 - GENERAL *(NOTE 1.1)*

1.1 WORK INCLUDED

A. Commissioning of selected systems and equipment specified under Division 15 Mechanical.

1.2 RELATED SECTIONS *(NOTE 1.2)*

A. Section 01810 Commissioning.

B. See individual Division 15 Sections for pre-functional checklists.

C. Section 15050 Basic Mechanical Materials and Methods.

D. Section 15950 Testing, Adjusting and Balancing.

E. Section 17959 EMCS Commissioning.

1.3 COMMISSIONING SCOPE

A. Fully commission the following equipment and systems:
1. Air handler units.
2. Packaged DX air conditioning or heat pumps.
3. Fan-coils.
4. Computer room air conditioning units.
5. Air distribution systems.
6. Terminal units.
7. Laboratory fume hood controls.
8. Exhaust and transfer fans.
9. Chilled water plant, including:
    a. Chillers
    b. Chilled water pumps
    c. Cooling towers
    d. Condenser water pumps
    e. Control valves (bypass valves, chiller/tower isolation valves, etc)
10. Hot water plant, including:
    a. Boilers
    b. Hot water pumps
    c. Control valves (bypass valves, isolation valves, etc)
11. Hot and chilled piping systems.
12. Variable speed drives.
13. Process air, gas and vacuum piping systems.
14. Laboratory air and vacuum equipment.
15. Emergency plumbing fixtures.
16. Service hot water systems.

17. Domestic water system distribution pumps.
18. Domestic water system booster pumps.
19. Domestic water heat exchanger.
20. Sump pump.

1.4 RESOURCES

A. Provide required personnel with tools and equipment necessary to perform testing specified in this Section.

B. Provide equipment factory representative for startup work as necessary or as specified.

PART 2 - PRODUCTS

2.1 GENERAL

A. Products and materials shall be as described in related sections.

PART 3 - EXECUTION

3.1 GENERAL

A. All tests and readings during the equipment and system start ups shall be recorded with signature of the Contractor’s technician performing work and date work was performed.

B. Verify that operational manual/procedures are complete, on-site, and fully reviewed by Contractor’s start-up technician prior to start-up and testing.

3.2 START-UP & INITIAL CHECKOUT

A. The Contractor shall follow the start-up and initial checkout procedures specified for each system and piece of equipment.

B. Inspect equipment and confirm that it is clean and ready for operation with all shipping tags and restraints removed.

C. This work shall be performed by the Contractor with the assistance of factory personnel where specified.

D. All tests and readings during the equipment and system start ups shall be recorded with signature of the Contractor’s technician performing work and date work was performed.

3.3 COMMISSIONING

A. Participate as a member of the Commissioning Team:

1. Commissioning Team, Commissioning Coordinator, Commissioning Schedule, and System/Equipment Matrix are defined in Section 01810 Commissioning.
2. Assist the Commissioning Coordinator in the creation and maintenance of the Commissioning Schedule and System/Equipment Matrix.
3. Provide regular feedback to the Commissioning Coordinator as to the status of tasks identified in the Commissioning Schedule.
4. Attend Commissioning Team Meetings.

B. Pre-Functional Tests:
   1. Prepare pre-functional checklists for each piece of equipment and each system listed in Section 1.3 using forms listed in each Division 15 specification section. Where forms are not provided Division 15 specification sections, prepare appropriate forms and submit to Owner's Representative for review.
   2. Verify that startup is complete prior to starting pre-functional testing.
   3. Provide all materials and labor, including testing and inspection, to complete the pre-functional checklists.
   4. Collect checklists and submit to the Owner's Representative for review and approval.
   5. Address Owner's Representative punch list items before functional testing begins.

C. Testing, Adjusting and Balancing:
   1. See Section 15950 Testing, Adjusting and Balancing.
   2. Complete test and balance of all air or hydronic systems, including spot checks, with discrepancies and problems remedied before functional testing begins.

D. Functional Testing:
   1. Functional testing is specified under Section 17959 EMCS Commissioning.
   2. Review functional test procedures to ensure feasibility, safety and equipment protection and provide revisions deemed to be necessary in writing to Commissioning Coordinator.
   3. Provide skilled personnel to assist Division 17 in the functional testing and demonstration of system performance. Coordinate required skills with Division 17.
   4. While functional testing is primarily performed under Division 17, the installing Division 15 Contractors shall retain responsibility for complete and fully functional systems and sub-systems installed under their contract. Commissioning procedures and functional testing do not relieve or lessen this responsibility.

E. Demonstration Tests:
   1. Demonstration testing is specified under Section 17959 EMCS Commissioning. No work required under this section.

F. Remedial Work: See Section 01810 Commissioning.

3.4 TRAINING

3.5 COMMISIONING REPORTS

A. For each piece of equipment or system listed in paragraph 1.3, provide the following where applicable:
   1. Start-up and Factory Test Reports.
   2. Piping Pressure Test Reports:
      a. See Section 15180 Heating and Cooling Piping.
      b. See Section 15140 Domestic Water Piping.
   3. Duct Pressure Test Reports. See Section 15810 Ducts.
   4. Duct Leakage Test Reports. See Section 15810 Ducts.

5. Pre-Functional Test Reports.
6. Testing, Adjusting, and Balancing Report. See Section 15950 Testing, Adjusting and Balancing.
7. Training Manuals.

B. Provide reports to Owner's Representative in quantities and format specified in Section 15050 Basic Mechanical Materials and Methods.

END OF SECTION

NOTES

SECTION 15970 - MECHANICAL COMMISSIONING - NOTES

NOTE 1:

1.1 This section includes commissioning for mechanical equipment and systems. The specific pre-functional checklists are in each mechanical section of the specifications.
Includes administrative and procedural requirements specific to this section. Review Division 1 General Requirements for general administrative and procedural requirements.

1.2 Related Sections – List other sections dealing with work directly related to this section. Listing should be limited to other sections with specific information that the reader might expect to find in this section and to those actually referenced in the section.
Edit to suit job requirements. Include only references directly affecting work of this section.

REFERENCES

SECTION 15990 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 QUALITY ASSURANCE

A. Prior to start of testing, adjusting and balancing, verify that required "Job Conditions" are met:
   1. Systems installation is complete and in full operation.
   2. Doors and windows are in place or under normal traffic conditions.

B. Verify that requirements for preparation for testing and balancing have been met for elements of each of the systems which require testing.

C. End result of balancing of air systems shall be satisfactory relationship of air pressures, flow directions, room temperatures, etc. Adjust initial setpoints listed (e.g. building static pressure, duct static pressure setpoint) so that measurements and adjustments in addition to drawing indications if necessary to result in satisfactory air balance.

1.2 SUBMITTALS

A. See Section 15050: GENERAL PROVISIONS, MECHANICAL

B. During preliminary list of materials submittal, furnish to Architect documentation that:
   1. Air Balance Company is member of Associated Air Balance Council, or National Environmental Balancing Bureau.
   2. It has satisfactorily balanced at least three systems of comparable type and size.
      a. Include list of such projects.
      b. Include sample forms for use in compiling and recording test and balance data.

C. Final submission shall include:
   1. Records and tabulations required hereinafter.
   2. Signature of registered professional mechanical engineer experienced in balancing HVAC systems.

D. At least fifteen days prior to starting field work, submit three copies of:
   1. Set of report forms filled out as to:
         i. Design flow values.
         ii. Installed equipment pressure drops.
         iii. Required CFM for air terminals.

E. Complete list of instruments proposed to be used.
   1. Organize in appropriate categories.
   2. Include data sheets for each.
   3. Show:
      a. Manufacturer and model number.
      b. Description and use when needed to further identify instrument.

c. Size or capacity range.
d. Latest calibration date.

4. Provide certification that:
   a. All instruments have been calibrated prior to tests.
   b. Instruments comply with requirements of AABC or NEBB for tests required.
5. Proposed method of balancing variable air volume systems to account for system diversity.

F. At least fifteen days prior to Contractor's request for final inspection, submit three copies of final reports, on applicable reporting forms, for review.

1. Schedule testing and balancing of parts of systems which is delayed due to seasonal, climatic, occupancy, or other conditions beyond control of Contractor, as early as proper conditions will allow, after consultation with Architect/Engineer.
2. Submit reports of delayed testing promptly after execution of those services.
3. Form of Final Reports:
   a. Each individual final reporting form must bear:
      i. Signature of person who recorded data.
      ii. Signature of air balance supervisor of reporting organization.
   b. When more than one certified organization performs total air balance services, firm having managerial responsibility shall make submittals.
   c. Identify instruments of all types which were used, and last date of calibration of each.

1.3 PROJECT REVIEW

A. Pre-Construction Review.

1. Review following documents:
   a. Contract documents:
      i. Drawings.
      ii. Specifications.
      iii. Addenda.
   b. Submittal data.
   c. Shop drawings.
   d. Temperature control drawings.
2. Assure that design intent is clearly understood.
3. Identify potential problems from standpoint of total system balance.
4. Review of specifications for:
   a. Scope of work.
   b. Special requirements.
   c. Items that will make balancing difficult or impossible.
5. Review of drawings for:
   a. Potential problems for total system balance.
      i. Location of balancing devices.

        - ii. Lack of balancing devices.
        - iii. General System layout.
        - iv. Architectural features.
        - v. Accessibility.
    - b. Most effective system balance procedures.
    - c. Scheduling and coordination requirements.
6. Review of submittal data for:
    - a. Completeness of data.
    - b. Conformity with contract documents.
    - c. Special instructions for use of balancing devices.
    - d. Factors for flow meters.
    - e. Limitations affecting accuracy of measurements.
    - f. Balancing forms shall show design data and submittal data where different.
    - g. Equipment performance data and curves.
7. Review of shop drawings for:
    - a. Potential problems for total system balance, as specified above for review of contract drawings.
8. Review of temperature control drawings for:
    - a. Thorough understanding of system functions.
    - b. Determining most effective total system balance procedure for minimum control manipulation.
        - i. Avoid disturbing calibration of control devices.
    - c. Coordinate required control manipulation with control contractor.
9. Submit report recommending addition and/or relocation of balancing devices, including, but not limited to:
    - a. Volume dampers.
    - b. Balancing valves.
    - c. Flow metering devices, for air and water.
    - d. Pressure and temperature measuring points.

B. Construction Review:

1. Make on-site visits during progress of construction.
    - a. Number of visits to be as required to perform the functions specified below.
2. Purpose of review:
    - a. Identify potential problem for performing total system balance.
    - b. Identify modifications which will affect air total system balance.
    - c. Schedule and coordinate total system balance with other work.
    - d. Identify conditions that could create hazardous environment for building occupants.
3. Typical activities:
    - a. Check that necessary balancing and measuring hardware is in place, and:
        - i. Located properly and accessibly.

ii. Installed correctly.

b. Identify and evaluate variations from system design.

c. Record data from equipment nameplates.

d. Identify and report possible restrictions in systems; such as:

i. Closed fire dampers.

ii. Long runs of flexible duct.

iii. Poorly designed duct fittings.

iv. Questionable piping connections.

v. (Others)

e. Verify that construction progress will not delay total system balance.

f. Identify best location for duct pitot tube traverses.

g. Identify scaffolding needs.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 CONTROL COORDINATION

A. Cooperate with control installer and equipment installer in making adjustments to following items as required to accomplish indicated performance:

B. Coordinate testing, balancing and adjustment functions with control systems installed under Section 15900: CONTROLS AND INSTRUMENTATION.

3.2 AIR SYSTEM BALANCING

A. General:

1. Check that filters are installed, free of bypass, and clean; type as specified.

a. Make allowance for air filter resistance at time of tests.

b. Air supply:

i. At design air quantity.

ii. Pressure drop across filter banks midway between drop for clean and dirty filters.

c. Submit written report that above was done.

2. In cooperation with Control Subcontractor, set adjustments of automatically operated dampers and valves to operate as indicated.

B. Air outlet balancing.

1. Test and adjust each diffuser, grille and register to within ±10 percent of design requirements.

a. Start with all dampers wide open.

b. Adjust dampers, starting with nearest to terminal unit or fan.

c. At least one damper should remain wide open at end of balance.

2. Adjust diffusers, throw pattern, grilles and registers to pattern shown on plans.

3. Return air grilles or slots in lights: No balance required.

4. Read and record:
    a. Identify each grille, diffuser and register as to location area, size, type and manufacturer In recorded tabulation and floor plan submitted.
    b. Required velocity/cfm.
    c. Test resultant velocity/cfm.
    d. Test resultant cfm after adjustments.

C. Air Terminal Box balancing
1. Pneumatic zone controls
    a. Adjust maximum and minimum air flow rates as indicated.
        i. Where minimum setpoint is below control capability, set to lowest setpoint possible.
    b. Recalibrate thermostat when work on zone is complete.
        i. Use hand-held thermometer with $\pm 0.5°F$ accuracy to measure space temperature. Allow steady-state to be reached before beginning calibration.
        ii. Set each thermostat output to midpoint of control range when setpoint is set equal to actual room temperature.
        iii. Document that recalibration was complete on balance form. Note thermostat faults, if any.
2. Direct Digital Controls
    a. Cooperate with Control Subcontractor to learn how to calibrate DDC zone controller using hand-held computer.
    b. Adjust DDC calibration constants so that actual box and outlet air flow rate matches DDC reading within 5%.
        i. Zero transmitter prior to test.
    c. Test flow at minimum volume setpoint. If DDC indicated flow deviates from measured flow by more than 10%:
        i. Calibrate DDC again if another calibration point is available.
        ii. If DDC can only calibrate to one point, adjust DDC minimum volume setpoint so that actual flow equals desired minimum, even though this will cause DDC to read improperly.
    d. Record all of the above in balance report.
    e. For VAV systems, establish minimum static pressure setpoint to be the duct pressure necessary to deliver design air flow at “worst” box. Setpoint shall be as low as possible; arbitrarily setting setpoint to high value is unacceptable. Start at a setpoint equal to ¼ of fan system total static pressure and only increase if zones are found to be starved.
3. Read and record:
    a. VAV maximum flow rate
    b. VAV minimum flow rate
    c. Fan-powered box fan flow rate
    d. Entering VAV static and total pressure

e. Leaving plenum static and total pressure
f. Entering drybulb temperature to reheat coil
g. Leaving supply air drybulb temperature from reheat coil.
h. Drybulb temperature in occupied zone at thermostat location.

D. Air System balancing:
1. Make pitot tube traverse of main supply return and exhaust ducts and obtain design cfm at fans.
   a. Total air quantities for all air-handling units shall be determined by pitot tube traverse of main ducts, traverse of filter banks or coils, and by totaling the readings of individual air outlets or terminal boxes. All three methods should be employed where possible so that comparisons can be made.
2. Total air quantities shall be obtained by adjustment of fan speeds.
   a. Fan speeds for VAV fans with variable speed drives shall not be adjusted by changing or adjusting sheaves; fans will automatically balance with drive.
3. Adjust main supply, return, and exhaust air ducts to proper design cfm.
4. Test and adjust minimum outside air system for design cfm.
   a. For systems with economizers, first set economizer dampers to closed or minimum position.
   b. Minimum outside air quantities shall be established by pitot tube traverse of outside air duct or louver, or by deduction from pitot traverse of return air and outside air ducts. Balance by measurement of return air, outside air, and mixed air temperatures shall NOT be used due to inherent inaccuracy.
   c. For VAV systems, determine static pressure across fixed minimum outdoor air damper at design minimum outdoor air flow. Convey to controls contractor and note on air balance report.
5. Test and record:
   a. Fan cfm at various locations measured.
   b. Fan speed and motor actual and full load amperes.
   c. Static pressures at:
      i. Return air plenum
      ii. Mixed air plenum
      iii. Downstream of filter
      iv. Downstream of coil
      v. Discharge of fans.
      vi. At static pressure sensor.
   d. Outside climatic conditions at time of testing:
      i. Drybulb (DB) and wetbulb (WB) temperatures.
      ii. Sunny, cloudy, windy, etc.
   e. Coil temperatures:
      i. Entering DB and WB to cooling coils.
      ii. Leaving supply air DB and WB from cooling coils.

iii. Coordinate with chilled water system test and balance described below.

E. Belt Drive Changes:
1. Make all changes in belts and sheaves required to obtain proper air balance.
2. At end of job, submit accounting of costs of additional drives.
3. Upon approval of Architect these costs form part of change order to contract.

3.3 WATER SYSTEMS BALANCING:

A. Prepare water systems for balancing in following manner:
1. Verify following conditions:
   a. Piping systems have been flushed and treated in accordance with Section 15060: PIPE AND PIPE FITTINGS.
   b. Strainers have been cleaned.
   c. Insides of traps, reducing and regulating valves have been cleaned.
   d. Expansion tanks are not air bound.
   e. Piping systems are completely full of water.
   f. Water systems are not air bound.
   g. Verify that air vents are installed and operating properly.
2. Check pump:
   a. Rotation.
   b. Pump impeller trimming by comparing "shut-off" heads with pump curves. Record in report.
3. Check operation of automatic valves, including automatic bypass valves.
4. DDC system must be capable of operating pumps, pump speeds, and bypass valve in automatic before balancing procedures can proceed.

B. Chilled Water System
1. System is variable flow with variable speed drives. Because of redundancy and diversity, sum of coil flow rates far exceeds pump and chiller capacity. For these reasons, the system cannot be balanced like a constant flow system
   a. Do not adjust any valves on any coil or pump.
   b. System is self-balancing via the controls.
   c. “Balancing” consists only of establishing control setpoints and verifying valve operation.
2. Balance procedure:
   a. Shut off all chillers.
   b. Close all chilled water control valves (via DDC system if possible, manually if not), except the critical branch, that which appears to have the highest pressure drop (start with AH-3 on 1st floor electrical room.).
   c. Start CHP-1. Manually adjust speed (via DDC or directly through VFD) until design flow is achieved (as indicated by coil pressure drop optionally verified by portable ultrasonic flow meter) through this critical branch without modulating any balance valves. Note the DDC system differential pressure reading at the DP sensor. This reading becomes the DP setpoint.
   d. Repeat step a) and b) for the most remote computer room unit on the 2nd floor. If the DP reading is higher, then this becomes the DP setpoint.

e. Repeat steps a) and b) for SF-5A/5B, the most remote AHU from the DP sensor. If the DP reading is higher, then this becomes the DP setpoint.

f. Close all valves in the system. Run CHP-1 pump and CHP-3 at full speed, dead-headed. Verify that all control valves remain shut with no measurable flow, as indicated by pump DP and any temperature rise across coils.

    i. Do not run pumps deadheaded for more than 10 minutes at any one time.

g. Allow bypass valve control loop to operate in auto. Valve should open to maintain minimum flow through chiller. Verify.

h. Convey DP setpoint to the Controls Subcontractor and note on balance report. Also convey any leaking valve problems to Controls Subcontractor so that they can be repaired or replaced.

3. Coil test.

    a. Test with:

        i. CHP-1 running in automatic maintaining DP setpoint determined above.

        ii. CH-1 running to maintain 42°F leaving water temperature.

        iii. A minimum number of coils open to keep CH-1 on line but without fully loading it.

    b. At each coil, when air balance is done on the coil and fan is running at design volume, open control valve, allow steady-state to be reached, and measure:

        i. Entering chilled water temperature

        ii. Leaving chilled water temperature

        iii. Coil differential pressure drop

        iv. Coil flow rate, deduced from manufacturer's coil data, supplemented optionally with portable ultrasonic meter measurement.

        v. Air entering conditions as specified above.

4. Chillers:

    a. With each chiller operating individually, one at a time, verify magnetic flow meter signal to DDC system with differential pressure readings across chiller and across pump. Compare and document.

    b. Chiller capacity and sequencing to be tested via commissioning procedure, by others.

C. Condenser Water System

1. Balance with CWP-1 and 2 on.

2. Modulate flow through chillers using chiller butterfly valves to achieve design flow within +20% and –5%.

    a. Do not modulate valve at pump discharge.

3. Balance flow through tower to be nearly equal based on observing water level with equalizer valve closed.

    a. Care must be taken not to draw a tower basin dry during this procedure.

    b. Fully open equalizer when complete.

4. Test and Record:

    a. Chiller inlet and outlet water pressures

b. Concurrent chilled water pump inlet and outlet pressures.
c. Tower inlet water pressure
d. Condenser water gpm, deduced from chiller pressure drop curves .

D. Hot Water System
1. No balance is required other than to equalize flows through boilers.
2. Run pumps with several reheat coil valves open to establish flow. Balance flow through boilers to be roughly equal based on hot water temperature rise with both boilers at high (or low) fire.
3. Record for each boiler:
a. Inlet and outlet hot water temperatures.
b. Inlet and outlet pressures
c. Concurrent hot water pump inlet and outlet pressures.

E. Submit as specified under Section 15050: GENERAL PROVISIONS, MECHANICAL.

END OF SECTION

CONTENTS

CONTENTS 1
DISCLAIMER 2
Section 16500 - Lighting 3
Section 16500 - Lighting - Notes 10

DISCLAIMER

The authors have tried to make the information in this document as accurate and useful as possible. However, they make no warranty, express or implied, and assume no legal liability for the information in this report. References to specific manufacturers or products are provided for the convenience of the reader and shall not be considered endorsements.

These specifications were prepared as a 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 warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

SECTION 16500 - LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Environmental Issues: Work includes special environmental considerations related to energy efficiency, indoor air quality, and resource efficiency; refer to Section 01350 – Special Environmental Requirements.

1.2 DEFINITIONS

A. Normal Light Output (NLO) ballasts: Ballasts with a ballast factor between 0.85 and .95.

B. Reduced Light Output (RLO) ballasts: Ballasts with a ballast factor of 0.85 or less.

C. High Light Output (HLO) ballasts: Ballasts with a ballast factor between 0.95 and 1.20.

D. NVLAP: National Voluntary Laboratory Accreditation Program, administered by National Institute of Standards and Technology (NIST) for commercial laboratories. One of the NVLAP areas of accreditation is for energy efficient lighting products.

1.3 SUBMITTALS *(Note 1.2)*

A. Submit in accordance with the procedures listed in Division 1 the following:

1. Data sheets for all luminaires, lamps, and ballasts listed on the Fixture Schedule.
2. Lamp submittals shall include data for rated lamp life, initial light output and lumen depreciation ratings at 40% and 80% of rated lamp life. Lamp submittals for directional lamps shall list center beam candle power and beam angle. (*Note 1.3)*
3. Ballast submittals shall be provided as part of the luminaire submittal. The submittal shall include the specific ballast manufacturer and model number and pertinent ballast data to demonstrate compliance with the ballast specifications.
4. A photometric test report for each luminaire type and lamp combination listed on the fixture schedule. Test reports shall be based on Illuminating Engineering Society published test procedures and shall contain all relevant candlepower distribution data as well as luminaire luminance data necessary to ensure compliance with design intent.

1.4 TESTING:

A. Test Reports: Certified Test Reports showing compliance with specified performance characteristics and physical properties. Testing by an independent lighting laboratory may be designated. Lamp tests from a NVLAP accredited laboratory may be designated. (*Note 1.4)*

1.5 OWNER'S INSTRUCTIONS

A. Product Record Documents shall include a copy of any owner's instructions available from the manufacturer of lighting equipment.

1.6 COMMISSIONING

A. All lighting controls shall be commissioned to ensure optimal performance and compliance with design intent. Commissioning shall be performed by (Commissioning Agent Identification) prior to occupancy but after all furnishings and finishes have been installed. *(Note 1.5)*

1. Either the manufacturer's representative or a trained technician shall implement the initial commissioning. *(Note 1.6)*

B. Energy management systems and other comprehensive control networks shall be commissioned as indicated by the system manufacturer, before accepting building spaces for occupancy.

1.7 MAINTENANCE

A. Replace lamps as a group after an interval specified by the lighting designer between 70 and 80% or rated lamp life. (*Note 1.7)*

B. Recycle spent fluorescent and HID lamps. (*Note 1.8)*

PART 2 - PRODUCTS

2.1 MATERIALS

A. Lamps:

1. General:
   a. Refer to Fixture Schedule for a list of all lamps.
   b. Lamps are specified by manufacturer name and model number for specific performance and environmental criteria. Only lamps of equal or better performance criteria will be acceptable.
   c. Directional lamps are specified by their center beam candlepower values, beam spreads, and wattages.
2. Linear Fluorescent Lamps:
   a. Linear fluorescent lamps shall comply with the latest state environmental laws for new lamps. *(Note 1.8)*
   b. Linear fluorescent lamps shall have a minimum Color Rendering Index (CRI) of 80. The color temperature (CCT) shall be __________°K. *(Fill in 3000, 3500, 4100, or 5000)* (*Note 1.9)*
   c. Linear fluorescent lamp efficacy shall be minimum 85 lumens per Watt (excluding ballast) based on rated initial lamp lumens.
   d. Lamp Lumen Depreciation (LLD) for linear fluorescent lamps shall result in a mean lumen value of at least 92% of the initial lamp lumens at 40% rated life and 89% of the initial lamp lumens at 80% rated lamp life.
   e. Mortality curves at 3 operating hours per start shall show that less than 15% of lamps fail before 70% of rated life.
   f. 32W F32T8 lamps shall have a minimum initial rated light output of 3100 lumens. *(Note 1.10)*
   g. T8 Linear 2', 3', 4', and 5' lamps shall have a minimum rated lamp life of 24,000 hours. (*Note 1.1)*
   h. T5 Linear 2', 3', 4', and 5' (nominal length) lamps shall have a minimum rated

lamp life of 20,000 hours.

3. Compact Fluorescent Lamps:
   a. Compact fluorescent lamps incorporating three twin tubes and four-pin bases shall contain amalgam.
   b. Compact fluorescent lamps shall have a minimum CRI of 80. The color temperature shall be __________°K. *(Fill in 2700, 3000, 3500, 4100, or 5000) (Note 1.9)*
   c. Compact fluorescent lamp efficacy, based on initial lamp rating, shall be minimum 60 lumens per Watt (excluding ballast).
   d. Lamp Lumen Depreciation (LLD) for linear fluorescent lamps shall result in a mean lumen value of at least 82% of the initial lamp lumens at 40% rated life and 75% of the initial lamp lumens at 80% rated lamp life.
   e. Mortality curves at 3 operating hours per start shall show that less than 20% of lamps fail before 70% of rated life.
   f. T5 Compact twin tube lamps shall have a minimum rated lamp life of 20,000 hours for 18 and 40 Watt lamps and 12,000 hours for 27 and 50 Watt lamps.
   g. T4 Compact twin, triple, quad and helical lamp types shall have a minimum rated lamp life of 10,000 hours.
4. HID Lamps:
   a. HID lamp bases shall either be welded or use lead-free solder. Pay particular attention to lamp starting method and ballast compatibility. (*Note 1.12)*
5. Halogen Lamps:
   a. Halogen lamps shall comply with the latest state environmental laws. If no state laws are in place, the minimum criteria shall be that the lamp bases shall only use solder that is lead-free.
   b. Halogen lamps shall employ Halogen Infrared Reflecting(IR) technology. Exceptions will be made for lamps that can demonstrate the same level of performance at identical or lower power (wattage). (*Note 1.13)*

B. Ballasts:
1. Refer to Fixture Schedule for a list of all ballasts used on projects.
2. Ballasts shall not contain pholychlorinated biphenyls (PCB's) and shall be labeled "NO PCB's" if they contain an internal capacitor. (*Note 1.14)*
3. Electronic Fluorescent High Frequency Ballasts:
   a. All Fluorescent ballasts (linear and compact) for lamps rated 15 Watts and above shall be electronic operating at a frequency of 20 KHz or greater. (*Note 1.15)*
   b. Fluorescent electronic ballasts shall be Normal Light Output, Reduced Light Output, or High Light Output, as noted in the fixture schedule.
   c. Total Harmonic Distortion shall not exceed 20%. (*Note 1.16).*
   d. Power Factor shall be 0.9 or greater. (*Note 1.17)*
   e. Lamp Current Crest Factor shall not exceed 1.7. (*Note 1.18)*
   f. Ballasts shall be regulated to maintain light output which does not vary more than ± 5% for all fluorescent lamps within operating ranges of ± 10% of rated system voltage.
   g. Ballasts shall have a warranty of not less than 5 years. (*Note 1.1)*

h. Compact fluorescent and T5 fluorescent ballasts shall employ end-of-life (EOL) circuitry to shut down the circuit at the end of the lamp life. (*Note 1.20)*

4. HID Ballasts:

a. Use electronic ballasts where specified, and any specific manufacturer if designated.

b. HID ballasts for indoor applications shall meet any sound rating specifications.

c. Total Harmonic Distortion shall not exceed 35 %. (*Note 1.16)*

d. Power Factor shall be 0.9 or greater. (*Note 1.17)*

e. Lamp Current Crest Factor shall not exceed 1.7. (*Note 1.18)*

2.2 EQUIPMENT

A. Luminaires:

1. Refer to Fixture Schedule for a list of all project luminaires.
2. For fluorescent luminaires, follow specified ballast wiring and switching arrangements to lamps. Tandem wiring, where specified, shall be provided as factory assembled whips in specified lengths. (*Note 1.21)*

B. Lighting Controls:

1. Refer to Lighting Control Schedule for a list of all project lighting control devices.
2. All lighting controls and associated equipment shall comply with applicable State, UL and National Electrical Code requirements, and shall be installed to conform with manufacturer's and code specifications.
3. All switching devices that control fluorescent ballasts shall employ zero-crossing switching technology, or otherwise be designed to withstand high inrush current that may be caused by electronic ballasts.
4. All occupancy (motion) sensors shall be approved by the California Energy Commission.
5. Any specified dimming ballasts shall be electronic (solid state).
6. Any photocells that control lighting equipment shall be compatible with the ballasts they control, and shall be installed as directed by the photocell and ballast manufacturers. Photocells shall comply with applicable State requirements.
7. Photocell and other sensors shall be installed with five feet of slack wire to permit subsequent relocation without the need for rewiring.
8. Occupancy sensors intended for use with HID systems (typically high-low operation) shall be designated by the manufacturer to be compatible with such dimming systems.
9. Control systems that include both occupancy sensors and photocells shall be installed as indicated by the control manufacturer to assure compatibility.
10. Before calibrating a dimming control system, all lamps shall be operated at full output for at least 100 hours to assure stable dimming operation.
11. Passive infrared occupancy sensors shall be "masked" as required to prevent sensors from detecting motion outside the area they are controlling. The masking material shall be provided by the occupancy sensor manufacturer expressly for this purpose.

12. Ultrasonic occupancy sensors shall be calibrated so that they detect motion only in the intended control space.

2.3 FINISHES

A. Painted finishes for luminaire housings and white painted reflectors shall be powder coat finishes. White painted reflector surfaces shall have reflectivity of 90% or higher.

2.4 SOURCE QUALITY CONTROL: RECYCLABILITY

A. Project goal is to provide products that are readily recyclable.

PART 3 - EXECUTION

3.1 COORDINATION

A. Architectural Plans shall govern exact ceiling construction and mounting conditions for all fixtures. Contractor shall be responsible for coordination of fixture mounting and compatibility with ceiling construction.

B. Fixtures in areas where exposed or concealed pipe and ductwork prevents direct access to the structural ceiling shall be provided with appropriate support system to suspend fixture below obstructions to avoid conflicts with same.

C. The contractor shall coordinate the locations of light fixtures in exposed construction areas with mechanical ductwork. Any conflicts shall be coordinated through the Architect.

D. Coordinate circuiting of the lighting with the electrical plans. Electrical connections and wiring methods shall conform to Division 16.

3.2 INSTALLATION

A. The contractor shall be responsible for handling and installation of fixtures including all supports, hangers and hardware necessary for a complete installation. Fixtures shall be clean, plumb, level, square, in straight lines, and without distortion. Remedy light leaks that may develop after installation of recessed or enclosed fixtures.

B. Lighting plans show conduit connections to all specified luminaires. However contractor may, at his discretion, use existing flexible wiring harnesses in lieu of conduit connections, provided all applicable code provisions are met.

C. Turn over project with all lamps in new and operating condition. Exception: for dimming system lamp seasoning requirements, refer to part 2.2-B-10.

3.3 FIXTURE SUPPORTS

A. Physical Supports:

1. Surface mounted fixtures solely supported by recessed boxes in a gypsum board ceiling shall have a 1 1/8" steel bar screwed or welded to the back of the box. This steel bar must be long enough to span two ceiling support channels and shall be attached to the channels by twisting wire around the bar and the support channel. For fixtures weighing over 50 pounds, provide fixture studs in recessed box.
2. Support surface mounted fixtures more than 18" wide at or near each corner, in addition to support from outlet box. Recessed downlights manufactured with

built-in brackets shall be supported by twisting wire around the bracket and two adjacent ceiling support channel runners on either side of fixture.

3. Recessed downlights manufactured with built-in brackets shall be supported by twisting wire around the bracket and two adjacent ceiling support channel runners on either side of fixture.
4. Where ceiling and/or wall construction or pipe and/or ductwork is such that mounting channels, strongbacks, trapezes, brackets, etc., are required to properly support fixtures, provide these supports under this Section, unless otherwise shown.
5. Support outlet boxes as specified in Section 16130: Boxes. Provide all boxes with grounding pigtail.
6. On concrete ceilings, use one of the following for supporting fixtures other than by outlet box:
    a. Preset concrete inserts, provided inserts are completely covered by the fixture canopy.
    b. 1/4" x appropriate length wedge type anchor.

B. Seismic Supports:

1. Recessed fluorescent fixtures in suspended ceilings shall be supported by connecting two fixture support wires to the fixture at diagonal opposite corners for fixtures weighing 56 pounds or less. Connect four wires, one at each corner for fixtures weighing more than 56 pounds.
2. Recessed incandescent or compact fluorescent downlight fixtures in suspended ceilings shall be supported by connecting at least one fixture support wire to the fixture housing.
3. All suspended fixtures shall be able to swing 45 degrees from vertical in any direction without obstruction.
4. All recessed fluorescent fixtures shall be furnished with earthquake clips where installed in tee bar ceiling.

3.4 IDENTIFICATION SYSTEM

A. All junction box cover plates for the lighting branch circuit system shall be clearly marked with a permanent black ink felt pen identifying the branch circuit (both panel designation and circuit number) contained in the box.

3.5 FIELD AIMING

A. The contractor shall allow time in the bid, and be responsible upon the installation of the light fixtures, for aiming and lamping fixtures as described in the fixture schedule. This aiming will be required to be performed at night under the direction of the owner's representative and the architect or engineer. The contractor shall be responsible for providing the labor and materials for field aiming including, but not limited to, special rigging or scaffolding, adjusting fixtures in field, testing of various lamps with each fixture, and/or testing of various lenses or louvers with fixtures, as directed by the architect or engineer.

3.6 CLEANING AND PROTECTION

A. Environmental Protection: Refer to Section 01350 – Special Environmental Requirements.

END OF SECTION

SECTION 16500 - LIGHTING - NOTES

JUSTIFICATION

1.1 *Guidelines for Specification Integrity* provides useful information for design professionals on how to write specifications with clarity and precision. It is also instructional about communicating with clients, manufacturers and manufacturers' agents concerning their standards of quality for lighting equipment to ensure that recommendations apply to every phase of a project's development.

1.2 Submittals must be coordinated with Division 1 specifications; otherwise they will most likely be dropped for existing Division 1 priorities.

1.3 Lamp lumen ratings at 40% of rated life are called "mean lumens". Ratings at 80% of rated life correspond to typical end-of-life for group lamp replacement cycles.

1.4 To verify any questionable claims, independent laboratory testing can show actual performance. If there is any doubt that a product could achieve performance claims, or if any product might not exhibit the quality of prior samples, laboratory tests will prove performance or lack thereof.

1.5 Occupancy sensors, dimming systems and other automatic lighting controls require commissioning to adjust and verify proper operation and programming for user compatibility and energy savings. Untuned lighting controls can actually create higher lighting energy use than simple on/off switching. In addition, poorly commissioned lighting controls will distract and annoy building occupants, leading to complaints and decommissioning of expensive lighting equipment. Initial commissioning should occur before accepting building spaces for occupancy, but after important furniture or other items that might influence control response have been placed in each space. Should any remedial commissioning become necessary, it should specifically avoid times that are inconvenient for the space occupants. Also, any expenses incurred by remedial commissioning will be the responsibility of the commissioning agent.

1.6 The commissioning agent shall instruct and train at least one permanent maintenance technician for the building in control adjustment procedures.; this may be part of the Systems Demonstration.

1.7 Group relamping is the most labor and cost saving method to replace the lamps in a lighting system. Group relamping should occur between 70 and 80% of rated lamp life. Spot relamping should replace failed lamps before the group relamping, as necessary for task and aesthetic requirements. All lamps used for spot replacement should have installation month and year prominently marked, so they can be reused for spot relamping after the group relamping. The date information is useful to ascertain the probable remaining life of the substitute lamp, a factor in selecting spot replacement lamps.

1.8 Special environmental considerations for lamps that contain mercury:

a. Almost all arc (fluorescent and HID) lamps contain mercury. Just a few high pressure sodium lamps are mercury-free, and these have limited applications. Compared to using incandescent mercury-free lamps, the

NOTES

increased efficacy from arc lamps more than compensates for the internal lamp mercury by saving power plant emissions.

b. Lighting equipment that contains mercury is not prohibited. However, when it is discarded it must either meet California EPA requirements for unregulated disposal or must be disposed or recycled in compliance with the California Universal Waste Rule (until California EPA prohibits disposal in 2006). Small toxic waste generators (less than 220 pounds per month) are allowed to put items such as fluorescent or HID lamps into landfills. Larger toxic waste generators must track and dispose of their Universal Waste at proper sites.

c. All lamp manufacturers and the Cal EPA recommend recycling spent lamps to minimize environmental effects. Using a California-authorized lamp recycler eliminates other waste disposal requirements.

d. The US EPA uses a Toxicity Characteristic Leaching Procedure (TCLP) test to determine if a lighting waste can be discarded without using toxic waste procedures. Only some fluorescent lamps, a group of HPS lamps and a very few metal halide lamps meet TCLP requirements. Since Cal EPA requirements are more stringent, they supercede US EPA requirements in California.

e. California EPA uses a Total Threshold Limit Concentration (TTLC) test instead of the TCLP test. Only a few fluorescent lamps, from one manufacturer, and a couple of HPS lamps pass this test. Cal EPA recommends recycling for all commercial spent lamps that contain mercury, weather they meet TTLC test requirements or not.

f. Since both Cal EPA and lamp manufacturers recommend recycling spent lamps, there is no restriction on buying or using non-TTLC complying lamps. The lamps become universal waste when discarded, so the recycling question becomes a maintenance need rather than a specifying or purchasing item.

1.9 Specifier should indicate the best CCT for fluorescent lamps. 3000K works well with incandescent lamps or if illuminance levels are low (such as 5 footcandles). 3500K is a neutral white; without other light sources it seems neither warm nor cool. 4100K seems cool and crisp, and implies a business atmosphere; it works well with higher illuminance levels such as 100 footcandles. 5000K seems similar to noontime daylight with blue sky. While 5000K seems too cool for many applications, some research suggests that the high scotopic output of these very cool lamps may enhance visual acuity.

1.10 Lighting specifiers are encouraged to use “2nd Generation” or “premium” F32T8 lamps. These lamps produce more light and render colors better than standard F32T8 lamps. Since they produce higher lumens, the specifier can use RLO electronic ballasts to produce equivalent light output as standard electronically-ballasted F32T8 systems with an associated energy savings of 19%-20%.

1.11 Linear fluorescent lamps should be T8 (unless other types perform better, such as T5 in small optical systems) and should be rated for long life. The 24,000 hour rated T8 lamps have better overall life-cycle cost than 20,000 hour rated 2, 3,and 4 foot lamps.

1.12 Ballast compatibility is an important issue, especially with both pulse and probe

NOTES

start metal halide lamps available. ANSI codes, often listed in lamp and ballast catalogs can show lamp-ballast compatibilities.

1.13 Halogen Infrared lamps are typically more efficient than non-infrared lamps, so they are cost effective in the long run. A few non-infrared halogen lamps use advanced optical techniques to provide performance equal to infrared types.

1.14 Toxic PCB insulating oil-filled capacitors were discontinued as ballast components about 1978. Since then, ballasts that contain capacitors state that they contain "no PCBs".

1.15 All ballasts that operate at frequencies of 20kHz and above use electronics (they usually contain small inductors as part of their electronic circuitry). Small fluorescent lamps (less than 15 watts, compact or linear) may use 60 Hz magnetic ballasts, with low power factor acceptable, since electronic ballast availability for these lamp types is still poor.

1.16 Total harmonic distortion (THD) above 0.3 (30%) might cause overheating in the wiring of some buildings. Almost all electronic fluorescent ballasts offer THD of 20% or better, while magnetic fluorescent ballasts may range up to about 30% THD. HID ballasts display THD up to 30%.

1.17 Power factor indicates how efficiently an electrical device uses the energy provided. A low power factor may complicate the wiring needs of an electric system, since the current would exceed the anticipated amount based on the power of the load. High power factor means 0.90 and above, and is often required by electric utilities to avoid a special charge. This measure is usually determined at the electric meter, but keeping ballasts' power factor high tends to minimize complications of compliance.

1.18 Lamp current crest factor, a typical ballast performance specification, may have detrimental effect on lamp life if it exceeds 1.7.

1.19 Electronic ballasts have wide acceptance, so ballast manufacturers no longer offer a cash credit to replace a ballast that fails prematurely.

1.20 T5 and smaller diameter lamps need a ballast circuit to shut down the lamp if an electrode fails; this prevents overheating the glass near the electrode. Overheating often causes separation of the lamp base from the glass, allowing toxic lamp materials to escape. Modern electronic ballasts for these lamps include this circuit, and usually so state in their specifications.

1.21 Rapid start and instant start connections for electronic ballasts have historically caused occasional problems, since the options are many. Factory luminaire pre-wiring can decrease some problems, but clear specification and communications is very important.

REFERENCES

2.1 Illuminating Engineering Society of North America. Lighting Handbook, Ninth Edition. New York, NY: IESNA. 2000.

2.2 New Buildings Institute, Advanced Lighting Guidelines 2001. White Salmon, WA: NBI. 2001.

2.3 International Association of Lighting Designers. Guidelines for Specification Integrity. Chicago, IL. 2000. *(Note 1.1)*

REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY

CONTENTS

CONTENTS 1
DISCLAIMER 2
SECTION 17050 - GENERAL ENERGY MANAGEMENT AND CONTROL SYSTEM 3
SECTION 17050 - GENERAL ENERGY MANAGEMENT AND CONTROL SYSTEM - NOTES . 6
SECTION 17051 - EMCS BASIC MATERIALS AND DEVICES 7
SECTION 17051 - EMCS BASIC MATERIALS AND DEVICES - NOTES 10
SECTION 17055 - EMCS SOFTWARE AND PROGRAMMING 11
SECTION 17055 - EMCS SOFTWARE AND PROGRAMMING - NOTES 14
SECTION 17058 - EMCS POINTS AND SEQUENCE OF OPERATION 15
SECTION 17058 - EMCS POINTS AND SEQUENCE OF OPERATION - NOTES 30
SECTION 17959 - EMCS SYSTEM COMMISSIONING 33
SECTION 17959 - EMCS SYSTEM COMMISSIONING - NOTES 42

DISCLAIMER

The authors have tried to make the information in this document as accurate and useful as possible. However, they make no warranty, express or implied, and assume no legal liability for the information in this report. References to specific manufacturers or products are provided for the convenience of the reader and shall not be considered endorsements.

These specifications were prepared as a 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 warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

SECTION 17050 - GENERAL ENERGY MANAGEMENT AND CONTROL SYSTEM

PART 1 - GENERAL *(NOTE 1.1)*

1.1 WORK INCLUDED

A. Contractor shall furnish and install a direct digital control and Energy Management and Control System (EMCS).

B. The systems to be controlled under work of this section include, but are not limited to the following:

1. HVAC Systems
2. Plumbing Systems
3. Irrigation Systems
4. Lighting
5. Building Electrical Systems
6. Site Utilities

1.2 RELATED WORK AND REQUIREMENTS

A. All work in every Section must also comply with such general conditions of the specifications as are applicable, including, but not limited to:

1. Instructions to Bidders.
2. General Conditions.
3. Special Conditions.
4. Supplementary Conditions.
5. Division 1 General Requirements Sections as specified hereinafter.

B. Other EMCS sections:

1. Section 17051 EMCS Basic Materials and Devices
2. Section 17052 EMCS Operator Interfaces
3. Section 17053 EMCS Field Panels
4. Section 17054 EMCS Communication Devices
5. Section 17055 EMCS Software and Programming
6. Section 17058 EMCS Points and Sequence of Operation
7. Section 17959 EMCS Commissioning

C. Coordination with other Divisions

D. Testing and Commissioning

1. Section 01810 Commissioning
2. Section 15950 Testing, Adjusting and Balancing
3. Section 15970 Mechanical Commissioning

1.3 SYSTEM PERFORMANCE

A. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. <u>This includes when system is collecting trend data for</u>

commissioning and for long term monitoring. (See Section 17959.) In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein, assuming no other simultaneous operator activity. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements. This does not apply to gateways and their interaction with non-EMCS-vendor equipment.

1. Object Command. The maximum time between an operator command via the operator interface to change an analog or binary point and the subsequent change in the controller shall be less than 5 seconds.
2. Object Scan. All changes of state and change of analog values will be transmitted over the network such that any data used or displayed at a controller or workstation will have been current within the previous 10 seconds.
3. Graphics Scan. The maximum time between an operator's selection of a graphic and it completely painting the screen and updating at least 10 points shall be less than 10 seconds.
4. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation or broadcast to pager (where so programmed) shall not exceed 10 seconds for a Level 1 or 2 alarm, 20 seconds for alarm levels 2 and 3, and 30 seconds for alarm levels 4 and 5. All workstations on the onsite network must receive alarms within 5 seconds of each other.
5. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The EMCS Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
6. Control Loop Performance. Programmable controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. See Section 01450 Quality Control.

B. Perform tests as required by authorities having jurisdiction.

C. See 17959 EMCS System Commissioning.

D. Repair or replace defective work, as directed by Owner's Representative in writing, at no additional cost to the Owner.

E. Restore or replace damaged work due to tests as directed by Owner's Representative in writing, at no additional cost to the Owner.

F. Restore or replace damaged work of others, due to tests, as directed by Owner's Representative in writing, at no additional cost to the Owner.

G. Remedial work shall be performed to the satisfaction of the Owner's Representative, at no additional cost to the Owner, including:

1. Work related to all Division 17 pre-functional, functional, and demonstration tests.
2. Division 17 work related to Section 15950 Testing, Adjusting and Balancing.

H. Remedial work shall include performing any commissioning or other tests related to remedial work an additional time at no additional cost to the Owner.

END OF SECTION

SECTION 17050 - GENERAL ENERGY MANAGEMENT AND CONTROL SYSTEM - NOTES

NOTE 1:

1.1 This is a subsection of a much larger specification for EMCS software. The subsections included address trending capability and commissioning only.

REFERENCES

SECTION 17051 - EMCS BASIC MATERIALS AND DEVICES

PART 1 - GENERAL (NOTE 1.1)

1.1 WORK INCLUDED

A. Provide and install the following:
   1. Field devices including control valves, control dampers, sensors, etc.

B. Refer to Section 17050 for general requirements.

C. Refer to Section 17058 for points list and specific device requirements.

1.2 RELATED WORK AND REQUIREMENTS

A. Section 17050 - General Energy Management and Control System (EMCS)

B. Section 17052 - EMCS Operator Interfaces

C. Section 17053 - EMCS Field Panels

D. Section 17054 - EMCS Communications Devices

E. Section 17055 - EMCS Software and Programming

F. Section 17058 - EMCS Points and Sequence of Operation

G. Section 17959 - EMCS Commissioning

1.3 GENERAL

A. Sensor selection, wiring method, use of transmitters, A-to-D conversion bits, etc. shall be selected and adjusted to provide end-to-end (fluid to display) accuracy at or better than those listed in the following table.

Measured Variable	**Reported Accuracy**
Space drybulb temperature	±1ºF
Ducted Air drybulb temperature	±0.5ºF
Mixed Air drybulb temperature	±1ºF
Outside Air drybulb temperature	±0.5ºF
Chilled and Condenser Water Temperature	±0.5ºF
Hot Water Temperature	±1ºF
Hot/Chilled Water Delta-T (supply to return)	±0.3ºF
Relative Humidity − general	±5% RH
Relative Humidity − process control rooms	±3% RH *(Note 1.2)*
Water Flow	±3% of full scale
Airflow (terminal)	±10% of full scale
Airflow (measuring stations)	±5% of full scale
Air Pressure (ducts)	±0.05”
Air Pressure (space)	±0.01”
Water Pressure	±2% of full scale
Electrical power	2% of reading
Carbon Dioxide (CO_2)	±75 ppm

PART 2 - PRODUCTS

2.1 CONTROL VALVES

A. Valve Selection

1. Valve type:
   a. Modulating 2-way or 3-way valves: globe or characterized ball type. Butterfly valves may also be used for applications requiring low valve authority (pressure drop 1 psi and less) such as cooling tower bypass and boiler bypass. Valves (in conjunction with actuator) shall have minimum rangeability of 50 to 1.
   b. Two-position: Butterfly or ball valves
2. Valve Characteristics:
   a. 2-way valves: Equal percentage or modified equal percentage.
   b. 3-way valves controlling cooling coils and condenser water heat exchangers: Linear.
   c. 3-way valves controlling heating coils: Equal percentage or modified equal percentage.
   d. Two-position valves: Not applicable.
3. Valve Sizing *(Note 2.1)*
   a. [Provide factory fabricated control valves of type, body material and pressure class indicated in valve schedule on drawings. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Control valves shall be equipped with heavy-duty actuators, and minimum close-off rating shall be as scheduled.] *(Note 2.2)*
   b. [Modulating Water: Size valve to achieve the following full-open pressure drop:
      i. Minimum pressure drop: Equal to pressure drop of coil or exchanger.
      ii. Maximum pressure drop:
         a) Hot and chilled water at bridge connection: 2 psi *(Note 2.4)*
         b) Hot water at coils: 2 psi
         c) Chilled water at coils: 5 psi *(Note 2.5)*
         d) Tower bypass: 1 psi
         e) Boiler bypass: 1 psi] *(Note 2.3)*
      iii. Three-way valves shall be selected for near minimum pressure drop. Two-way valves shall be selected near maximum pressure drop.
      iv. Flow coefficient (Cv) shall not be less than 1.0 (to avoid clogging).
   c. Modulating Steam:
      i. The outlet pressure of valves for converters shall be no less than the inlet pressure required for the converters as given in plans for project.
      ii. As limited above, size modulating valves for applications of 15 psig or less for 80% of inlet gage pressure unless otherwise indicated.
      iii. As limited above, modulating valves for applications of greater than 15 psig shall be sized for 42% of inlet absolute pressure unless otherwise indicated.
   d. Two-position valves: Line size unless otherwise indicated.

2.2 DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. VAV Velocity Pressure:

1. Flow transducer (including impact of A-to-D conversion) shall be capable of stably controlling to a setpoint of 0.004” differential pressure or lower, shall be capable of sensing 0.002” differential pressure or lower, and shall have a ±0.001” or lower resolution across the entire scale. *(Note 2.7)*

PART 3 - EXECUTION

3.1 INSTALLATION OF SENSORS

A. Remote pressure sensors. To meet the requirements of this section, differential pressure sensors controlling fans and pumps shall either be home-run wired back to the CU controlling the fan/pump VFD; or install another DP sensor (not shown in points list) near the fan/pump and connected to the CU controlling the pump, connect remote sensors to remote CUs, and use cascading control loops (remote sensor loops reset setpoint for local sensor loop via the network, and local sensor loop controls the pump/fan). *(Note 3.1)*

B. Differential Pressure Sensors:

1. Supply Duct Static Pressure: Locate transmitter in temperature control panel near or in DDC panel to which it is wired. Connect the low-pressure port to tee in building pressure (high) signal of the building static pressure transmitter. Pipe the high-pressure tap to the duct using a static pressure tip. Locate static pressure tip as shown on drawings; if no location is shown, locate at end of duct riser or main as far out in the system as possible but upstream of all smoke and fire dampers. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer’s installation instructions. *(Note 3.2)*

2. Building Static Pressure:

   a. Low pressure port of the pressure sensor:

      i. Pipe to the ambient static pressure probe located on the outside and at high point of the building through a high-volume accumulator or otherwise protected from wind fluctuations.

   b. High-pressure port of the pressure sensor:

      i. Pipe to either:

         a) Behind a DDC temperature sensor cover in an interior zone.

         b) Bosco or Dwyer plate sensor mounted in ceiling.

      ii. Do not locate near elevators, exterior doors, atria, or (for ceiling sensor applications) near diffusers. *(Note 3.3)*

END OF SECTION

N
O
T
E
S

SECTION 17051 - EMCS BASIC MATERIALS AND DEVICES - NOTES

NOTE 1:

1.1 This is a subsection of a much larger specification for EMCS sensors and other hardware. The subsections included address some often overlooked details that affect system energy performance.

1.2 May need to be more accurate for some research applications.

NOTE 2:

2.1 Valve Sizing: Recommended "valve authority" approach (per ASHRAE). Modulating valves shall be sized for maximum full flow pressure drop between 50% and 100% of the branch circuit it is controlling. The branch circuit is defined as the point of connection at which flow variations through the valve will have little impact on differential pressure across the branch.

Control valve sizing and selection should be the initial responsibility of the AE and should NOT be left to the controls subcontractor since the contractor will have no way of knowing what the branch pressure drops are (see sizing method described above). AE should provide a valve schedule that lists the requirements of the valves for Cv range, close off pressure ratings, temperature etc.

2.2 Applicable only if a valve schedule is included. Delete if there is no valve schedule.

2.3 Applicable only if a valve schedule is NOT included. Delete if there is a valve schedule.

2.4 The pressure drop of the branch is very small – only that due to the basket strainer and generally minimal piping to the mains. Hence adequate valve authority is achieved with very low pressure drop

2.5 May want to adjust up or down depending on circuit pressure drop to achieve a valve authority of 0.5. This will require a circuit pressure drop analysis.

2.7 Being able to stably control down to 0.004" is important for being able to set a low minimum flow setpoint on VAV boxes. The lower the minimum flow the less wasted reheat energy Most flow transducers with 10 bit A/D conversion (or higher) can stably control down to 0.004".

NOTE 3:

3.1 If the differential pressure sensor is connected to one CU and the fan/pump is connected to another then network traffic could cause control instability in the fan/pump control.

3.2 The further out in the supply ductwork the ΔP sensor is located the greater the potential for fan energy savings.

3.3 Pressure fluctuation near elevators, exterior doors, atria will cause the controls to be unstable.

REFERENCE

SECTION 17055 - EMCS SOFTWARE AND PROGRAMMING

PART 1 - GENERAL (NOTE 1.1)

1.1 WORK INCLUDED

A. Provide and install the following:
   1. System Software
   2. Programming Software
   3. Graphical User Interface Software

B. Refer to Section 17050 for general requirements.

1.2 RELATED WORK AND REQUIREMENTS

A. Section 17050 Energy Management and Control System (EMCS) − General

B. Section 17051 EMCS Basic Materials and Devices

C. Section 17052 EMCS Operator Interfaces

D. Section 17053 EMCS Field Panels

E. Section 17054 EMCS Communication Devices

F. Section 17058 EMCS Points and Sequence of Operation

G. Section 17959 EMCS Commissioning

H. Section 15950 Testing, Adjusting, and Balancing

1.3 GENERAL

PART 2 - PRODUCTS

2.1 GRAPHICAL USER INTERFACE SOFTWARE

A. Trends *(Note 2.1)*
   1. Trending and trend analysis capabilities are considered critical to system performance. The system shall be designed to upload and record large amounts of point data without causing network bottlenecks or affecting proper system operation.
   2. Every point, both real and virtual, shall be available for data trending.
   3. Trending software shall be capable of recording point values and time on a user specified regular time step and on a change-of-value (COV) basis (data is recorded when point changes by a specified amount for analog points or by changes of state for binary points), at the user's option. Sampling intervals shall be as small as one second. Each trended point shall have the ability to be trended at a different sampling interval.
   4. Trend data shall be sampled and stored in control panel memory (see Section 17053). If historical trending is enabled for the BACnet object, trend data shall be uploaded from control panels to the Operator Workstation on a user-defined interval, manual command, or automatically when the trend buffer becomes full. There shall be no limit to the amount of trend data stored at the Operator Workstation other than hard disk limitations.

5. Trends shall conform to the BACnet Trend Log Object specification. Trends shall both be displayed and user configurable through the GUI. Trend logs may comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.
6. Viewing Trends:
    a. Trend data shall be displayed graphically by the GUI. This shall be a capability internal to the workstation software and not a capability resulting from download of trend data on a third-party spreadsheet program unless such transfer is automatic and transparent to the operation and the third-party software is included with the workstation software package.
    b. The software shall be capable of dynamically graphing the trend logged object data by creating two-axis (x, y) graphs that simultaneously display values relative to time for at least eight objects in different colors, even if objects have been trended at different time intervals. Where trended values are COV, software shall automatically fill the trend samples between COV entries. A graph legend shall identify each variable plotted.
    c. Multiple scales shall be possible, one for each object, with range set automatically by the software but capable of being manually adjusted by the operator.
    d. Trend format, displayed points, etc. shall be capable of being saved as a template for future trend displays.
    e. Trends shall be able to dynamically update at operator-defined intervals, including on a 1 second interval for loop tuning.
    f. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.
    g. It shall be possible to pick (or float mouse over) any sample on a trend and have the numerical value displayed.
    h. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard Windows keystrokes.
7. Provide software to archive trend data to CD.
8. Data storage for analysis by other software.
    a. Data shall be stored in or exportable to one or more of the following formats for:
        i. Text (Comma or tab delimited with “” text delimiters)
        ii. MS Excel
        iii. MS Access
        iv. dBase
        v. SQL
    b. Stored data shall have the following characteristics:
        i. There shall be no duplicate records. Each time/date stamp for a specific point shall be unique.
        ii. The data shall be fully contained in a single file or table for each point. Data shall not span multiple files or database tables.

iii. Each field of data shall have one and only one unique identifier. The label shall be in the first row of the file. Labels should not be repeated in the stream of data.

iv. Each table or file shall have a single date/time stamp. Multiple fields that are sampled on the same time stamp can be combined in a single file or table provided that they have the same number of records and are stored in the following format:

Date/Time	Field 1	Field2	…	Field n
DateTimeValue$_1$	Value 1_1	Value 2_1	…	Value n_1
DateTimeValue$_j$	Value 1_j	Value 2_j	…	Value n_j

v. Date/Time fields shall be in a single column in a format automatically recognized by MS Access or MS Excel.

B. Security Access

C. Report Software

PART 3 - EXECUTION

END OF SECTION

NOTES

SECTION 17055 - EMCS SOFTWARE AND PROGRAMMING - NOTES

NOTE 1:

1.1 This is a subsection of a much larger specification for EMCS software. The subsection included establishes trending capability and the ability to extract the data for external viewing and analysis. This is used to assist in the commissioning process and diagnosing operating problems during normal operation. Almost all DDC systems have trending capability, but many do it very poorly, particularly if there is not a specification requiring extensive trending capability.

NOTE 2:

2.1 The ability of the control system to properly trend all the required points is absolutely critical for commissioning the HVAC and lighting control systems in terms of being able to review actual operation and confirm that all sequences of operation have been properly implemented. Successful trending requires that the network architecture be sufficiently robust that the network does not get bogged down by the trending requirements. This wording is designed around BACnet systems; revision is required for other system architectures.

REFERENCES

SECTION 17058 - EMCS POINTS AND SEQUENCE OF OPERATION

PART 1 - GENERAL (NOTE 1.1)

1.1 WORK INCLUDED

A. This section defines:
1. Real I/O points connected to the EMCS.
2. Sequence of operation of all controlled systems.

B. Refer to Section 17050 for general requirements.

1.2 RELATED WORK AND REQUIREMENTS

A. Section 17050 - Energy Management and Control System (EMCS) − General

B. Section 17051 - EMCS Basic Materials and Devices

C. Section 17052 - EMCS Operator Interfaces

D. Section 17053 - EMCS Field Panels

E. Section 17054 - EMCS Communication Devices

F. Section 17055 - EMCS Software and Programming

G. Section 17959 - EMCS Commissioning

H. Section 15950 - Testing, Adjusting, and Balancing

1.3 GENERAL

PART 2 - PRODUCTS

2.1 CONTROL POINTS

A. Table Column Definitions
1. Point Description
2. Type (number in point schedule after each type refers to tag on schematics)
   a. AO: Analog Output
   b. AI: Analog Input
   c. DO: Digital or Binary Output
   d. DI: Digital or Binary Input
3. Device Description
   a. See Section 17051 for device definition.
4. Trend Logging *(Note 2.1)*
   a. Commissioning: Where listed, point is to be trended at the basis listed for commissioning and performance verification purposes. Trend may be deactivated after acceptance.
   b. Continuous: Where listed, point is to be trended at the basis listed continuously, initiated after system acceptance, for the purpose of future diagnostics.
   c. Trend Basis:

i. Where range of engineering units is listed, trend on a change of value (COV) basis (i.e. record time stamp and value when point value changes by engineering unit listed)

ii. Where time interval is listed, trend on a time basis (i.e. record time stamp and value at interval listed). All points relating to a specific piece of equipment shall be trended at the same initiation time of day so data can be compared in text format.

5. Calibration *(Note 2.2)*
   a. F = factory calibration only is required (no field calibration)
   b. HH = field calibrate with handheld device. See Calibration in Section 17959.
   c. DB = field calibrate with a drywell bath. See Calibration in Section 17959.

B. Note that points lists below are for <u>each</u> system of like kind. Refer to drawings for quantity of each. *(Note 2.3)*

C. Variable speed drives (typical of VFD driven fans and pumps): The following points shall be mapped over from the VFD network card as a minimum for each pump or fan that has a variable speed drive:

Description	Type	Device	Trend Logging		Calibration
			Commissioning	Continuous	
On/off status	DI	Through network	COV	COV	–
VFD in local “hand” mode	DI	Through network	COV	COV	–
Alarm	DI	Through network	COV	COV	–
Actual speed	AI	Through network	1 min	–	–
Power	AI	Through network	1 min	15 min	F

D. VAV Air Handler with Return Fan (in addition to points mapped over from VFDs)

Description	Type/ Tag	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Minimum outdoor air damper open/close	DO-1	Two position actuator	COV	COV	–
Return fan high static alarm reset	DO-2	Dry contact to 120V or 24V control circuit –see control sequences for details	COV	COV	–
Return Fan Start/Stop	DO-3	Connect to VFD “Run”	COV	COV	–
Supply fan high static alarm reset	DO-4	Dry contact to 120V or 24V control circuit –see control sequences for details	COV	COV	–
Supply Fan Start/Stop	DO-5	Connect to VFD “Run”	COV	COV	–
Exhaust Air Damper	AO-1	Modulating actuator	1 min	15 min	–
Economizer Outdoor Air Damper	AO-2	Modulating actuator	1 min	15 min	–
Return Air Damper	AO-3	Modulating actuator	1 min	15 min	–
Relief Fan Speed	AO-4	Connect to VFD “Speed”	1 min	15 min	–

Description	Type/ Tag	Device	Trend Logging		Calibration
			Commissioning	Continuous	
Hot Water Control Valve	AO-5	Modulating 2-way valve	1 min	15 min	–
Chilled Water Control Valve	AO-6	Modulating 2-way valve	1 min	15 min	–
Supply Fan Speed	AO-7	Connect to VFD “Speed”	1 min	15 min	–
Return Fan Static Pressure	AI-1	DPT-4A, 0 to 0.5”	1 min	15 min	F
Differential Pressure across OA damper (for min OA control)	AI-2	DPT-4A, 0 to 0.2”	1 min	15 min	F
Mixed Air Temperature	AI-3	TS-1B across filter bank	1 min	15 min	F
Filter Pressure Drop	AI-4	DPT-3A, 0 to 1”	–	60 min	F
Return Fan Airflow	AI-5	AFMS-1 and DPT.	1 min	15 min	F
CHW Return Temperature	AI-6	TS-2	1 min	15 min	F
Return Air Temperature	AI-7	TS-1A	1 min	15 min	F
Supply Fan Airflow	AI-8	AFMS-1 and DPT.	1 min	15 min	F
Supply Air Temperature	AI-9	TS-1A	1 min	15 min	HH
Duct Static Pressure	AI-10	DPT-3A, 0 to 2”	1 min	15 min	F

PART 3 - EXECUTION *(NOTE 3.1)*

3.1 SEQUENCE OF OPERATION

A. General

1. Control sequences listed below are to be the basis of the bid. EMCS Contractor shall review them prior to programming and suggest modifications where he/she feels performance will be improved.
2. Bids shall include costs for minor program modifications if required to provide stable performance of the system.
3. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent wind-up.
4. The term “PID loop” is used generically for all control loops and shall not be interpreted as requiring proportional plus integral plus derivative gains on all loops. Unless specifically indicated otherwise, the following guidelines shall be followed:
   a. Use proportional only (P-only) loops for limiting loops (such as CHW/HW flow limiting loops at bridge connections, zone CO_2 limiting loops, etc.) to ensure there is no integral windup.
   b. Do not use the derivative term on any loops unless field tuning is not possible without it.
5. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be capable of being adjusted by the operator without having to access programming whether indicated as “adjustable” in sequences or not. Software (virtual) points shall be used for these setpoints. Fixed scalar numbers shall not be imbedded in programs unless the value will never need to be adjusted.
6. Where zone data (e.g. damper or valve position, control loop signal) is used for reset of the AHU/pump system serving the zone, the zone tag (name) and

damper/valve position shall be recorded when it is the zone driving the reset (e.g. zone requiring the most cooling). This data shall be available for Reports (see 17055) so that zones that are undersized or otherwise driving the system can be identified for remediation if required. The position of the most open damper/valve is also critical for commissioning the reset sequences.

B. Zones: *(Note 3.2)*

1. This section applies to all single zone systems and sub-zones of air handling systems, such as VAV boxes, fan-powered boxes, etc.

2. Setpoints

   a. Each zone shall have separate unoccupied and occupied setpoints, and separate heating and cooling setpoint.

      i. As a default, the occupied heating setpoint shall be 70°F and the occupied cooling setpoint shall be 74°F in exterior zones and 73°F interior zones.

      ii. As a default, the unoccupied heating setpoint shall be 60°F and the unoccupied cooling setpoint shall be 90°F.

   b. The software shall prevent:

      i. the heating setpoint from exceeding the cooling setpoint minus 1°F (i.e. the minimum deadband shall be 1°F);

      ii. the unoccupied heating setpoint from exceeding the occupied heating setpoint; and

      iii. the unoccupied cooling setpoint from being less than the occupied cooling setpoint.

   c. Where the zone has a local occupant adjustable setpoint adjustment knob/button:

      i. The adjustment shall be capable of being limited in software.

         a) As a default, occupied cooling setpoint shall be limited between 72°F and 80°F.

         b) As a default, occupied heating setpoint shall be limited between 65°F and 72°F.

      ii. The adjustment shall move both the existing heating and cooling setpoints upwards or downwards by the same amount unless the limit has been reached.

      iii. The adjustment shall only be active in occupied mode.

      iv. If a demand limit setpoint adjustment is in place or the window switch indicates the window is open, the local setpoint adjustment shall be disabled.

   d. Demand limit setpoint adjustment. Cooling setpoints shall be increased upon demand limit requests from the associated Isolation Area.

      i. At Demand Limit Level 1, increase current setpoint by 1°F.

      ii. At Demand Limit Level 2, increase current setpoint by 2°F.

      iii. At Demand Limit Level 3, increase current setpoint by 4°F.

   e. Window switches. For zones that have operable windows with indicator switches, when the window switch indicates the window is open, the heating setpoint shall be temporarily set to 40°F and the cooling setpoint shall be temporarily set to 120°F.
   f. Occupancy sensors. For zones that have an occupancy switch associated with the zone, when the switch indicates the space is unoccupied during the Occupied mode, the heating setpoint shall be reset to 4°F lower than the active setpoint and the cooling setpoint shall be reset to 4°F higher than the active setpoint.
   g. The operative setpoint shall be determined by the Isolation Area's mode:
      i. The setpoints shall be the occupied setpoint during Occupied mode, Warm-up mode, and Cool-down mode.
      ii. The setpoints shall be unoccupied setpoints during Unoccupied mode, Setback mode, and Setup mode.
   h. Hierarchy of setpoint adjustments. The following adjustment restrictions shall prevail in order from highest to lowest priority:
      i. Setpoint overlap restriction (§ 3.1B.2.b.i).
      ii. Window switches.
      iii. Demand limit.
      iv. Occupancy sensors.
      v. Local setpoint adjustment.
      vi. Scheduled setpoints based on Isolation Area mode.
3. Local override. When thermostat override buttons are depressed, the request for Occupied Mode operation shall be sent up to the Isolation Area control for 60 minutes. (This will cause all zones in the Isolation Area to operate in Occupied Mode to ensure that the system has adequate load to operate stably.)
4. Control Loops:
   a. Two separate control loops shall operate to maintain space temperature at setpoint, the Cooling Loop and the Heating Loop. Both loops shall be continuously active.
   b. The Cooling Loop shall maintain the space temperature at the active cooling setpoint. The output of the loop shall be a virtual point ranging from 0% (no cooling) to +100% (full cooling).
   c. The Heating Loop shall maintain the space temperature at the active heating setpoint. The output of the loop shall be a virtual point ranging from 0% (no heating) to −100% (full heating).
   d. Loops shall be use proportional + integral logic or fuzzy logic. Proportional-only control is not acceptable, although the integral gain shall be small relative to the proportional gain. P and I gains shall be adjustable from the Operator Workstation.
   e. See other sections for how the outputs from these loops are used.
5. Zone Modes:
   a. Heating Mode: when the output of the space heating control loop is greater than zero.

b. Cooling Mode: when the output of the space cooling control loop is greater than zero and the output of the heating loop is equal to zero.

c. Deadband Mode: when not in either the Heating or Cooling Mode.

6. Alarms:

a. Inhibit alarms after zone setpoint is changed for a period of 10 minutes per degree of change (e.g. if setpoint changes from 68°F to 70°F, inhibit alarm for 20 minutes after the change) and while Isolation Area is in Warm-up or Cool-down Modes.

b. If the zone is 2°F above cooling or below heating setpoint, generate Level 3 alarm.

c. If the zone is 4°F above cooling or below heating setpoint, generate Level 2 alarm.

d. For zones with CO_2 sensors, if the CO_2 concentration is less than 300 ppm, or the zone is in unoccupied mode for more than 2 hours and zone CO_2 concentration exceeds 600 ppm, generate a level 3 alarm, indicating sensor may be out of calibration.

e. For zones with window switches, generate a level 4 alarm if the window switch is open and the zone is in unoccupied mode.

C. VAV Reheat boxes:

1. See § 3.1A. for setpoints, loops, and control modes.

2. Design airflow rates:

a. Zone design maximum cooling (Vcool-max) and maximum heating airflow setpoints (Vheat-max) shall be as scheduled on plans. *(Note 3.3)* For zones with CO_2 controls and occupancy sensors, the zone minimum (Vmin) shall be equal to 0.15 cfm/ft^2 times the room area. *(Note 3.4)*

c. For zones without CO_2 controls or occupancy sensors, the zone minimum (Vmin) shall be equal to 0.15 cfm/ft^2 times the room area or 15 cfm per person, whichever is larger. *(Note 3.5)*

3. The occupied minimum Vmin* shall be equal to Vmin except as follows:

a. If Vmin is non-zero and less than the lowest possible airflow setpoint allowed by the controls (Vm), Vmin* shall be set equal to Vm. The minimum setpoint Vm shall be determined as follows:

i. Determine the velocity pressure sensor reading VP_m in inches H_2O that results in a digital reading from the transducer and A/D converter of 12 bits or counts (assuming a 10 bit A/D converter). This is considered sufficient resolution for stable control. For Automated Logic, this equates to 0.004".

ii. Using the velocity pressure sensor amplification factor F provided by the sensor manufacturer for each VAV box sensor size, calculated the minimum velocity v_m for each VAV box size as:

$$v_m = 4005\sqrt{\frac{VP_m}{F}}$$

Where F is not known it can be calculated from the measured CFM at 1" signal from the VP sensor:

$$F = \left(\frac{4005A}{CFM_{@1"}} \right)^2$$

where A is the nominal duct area (ft^2), equal to:

$$A = \pi \left(\frac{D}{24} \right)^2$$

where D is the nominal duct diameter (inches).

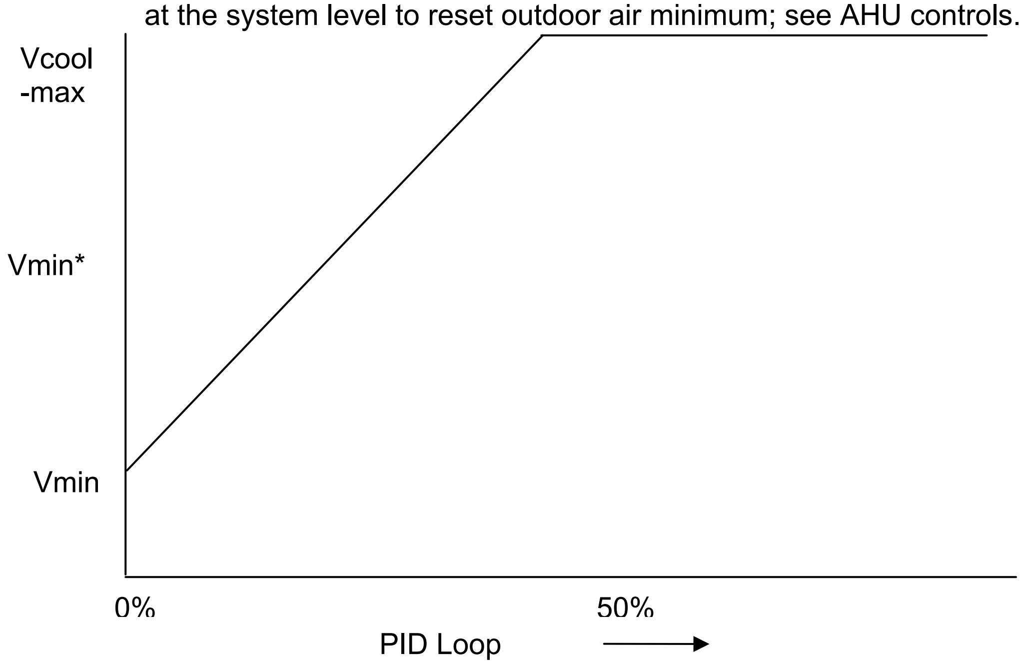
iii. Calculate the minimum airflow setpoint allowed by the controls (*Vm*) for each VAV box size as:

$$Vm = v_m A$$

b. If the VAV box is tied to an occupancy sensor, Vmin* shall be Vmin when the room is unoccupied while the zone is in Occupied mode. *(Note 3.6)*

c. If the VAV box is tied to a window switch, Vmin* shall be zero when the window is open.

d. If the zone has a CO_2 sensor, during Occupied Mode, a P-only loop shall maintain CO_2 concentration at 1000 ppm. The output of this loop (0 to 100%) shall be mapped as shown below. The loop output from 0 to 50% shall reset the minimum airflow setpoint to the zone from Vmin up to maximum cooling airflow setpoint Vcool-max. The loop output from 50% to 100% will be used at the system level to reset outdoor air minimum; see AHU controls.

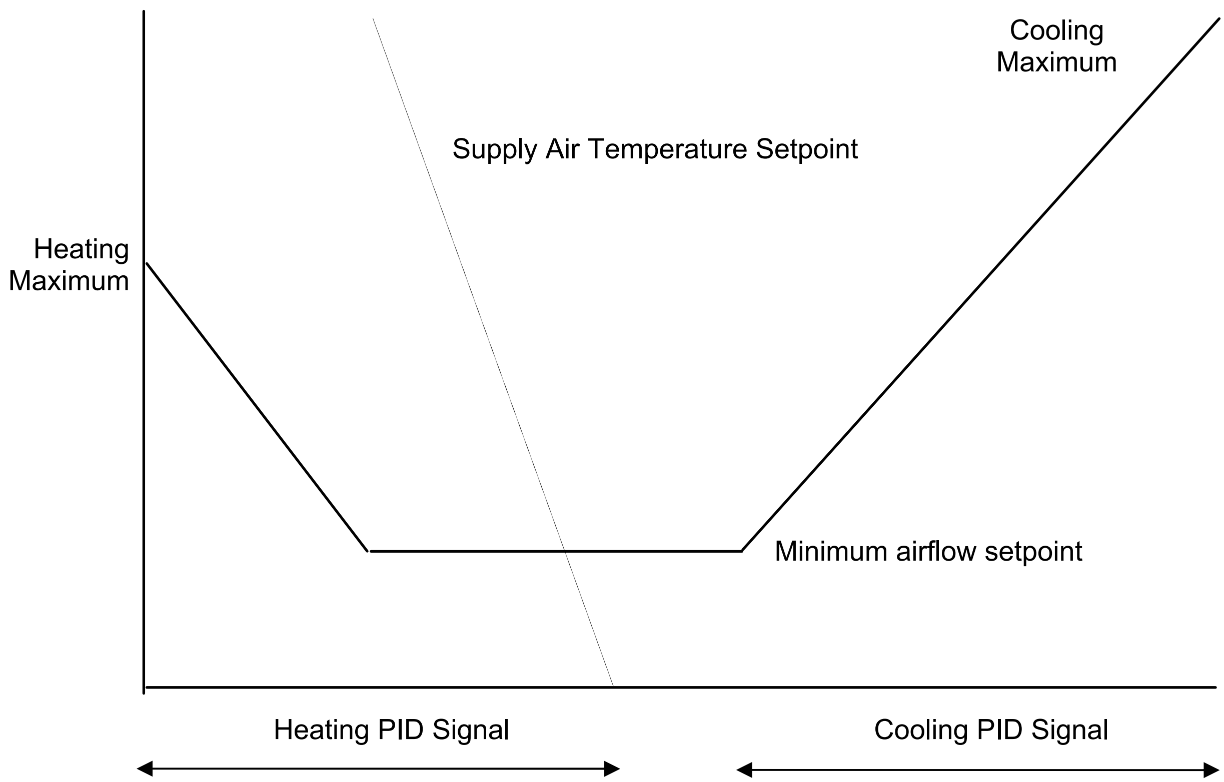


4. Active cooling maximum and minimum setpoints shall vary depending on the mode of the Isolation Area the zone is a part of:

Setpoint	Occupied	Cool-down	Setup	Warm-up	Setback	Unoccupied
Cooling maximum	Vcool-max	Vcool-max	Vcool-max	0	0	0

Setpoint	Occupied	Cool-down	Setup	Warm-up	Setback	Unoccupied
Minimum	Vmin*	0	0	0	0	0
Heating maximum	Vheat-max	Vheat-max	Vheat-max	Vcool-max	Vcool-max	0

5. Control logic is depicted schematically in the figure below and described in the following sections.



a. When the zone is in the Cooling Mode, the Cooling Loop output shall be mapped to the airflow setpoint from the cooling maximum to the minimum airflow setpoints. Hot water valve is closed.
b. When the zone is in the Deadband Mode, the airflow setpoint shall be the minimum airflow setpoint. Hot water valve is closed.
c. When the zone is in the Heating Mode, the Heating Loop shall maintain space temperature at the heating setpoint as follows:
    i. From 0-50%, the Heating Loop output shall reset the discharge temperature from 55°F to 95°F. *(Note 3.7)*
    ii. From 50%-100%, the Heating Loop output shall reset the zone airflow setpoint from the minimum airflow setpoint to the maximum heating airflow setpoint.
    iii. The hot water valve shall be modulated using P+I loop to maintain the discharge temperature at setpoint. (Directly controlling HW valve off zone temperature PID loop is not acceptable.)
d. The VAV damper shall be modulated to maintain the measured airflow at setpoint.

6. Automatic recalibration:
   a. Damper position estimate: If damper position on a floating damper actuator is estimated by counting open/close pulses, the position shall be recalibrated to 0% when the damper is known to be closed (more than enough close pulses to ensure damper is closed) and to 100% when damper is known to be fully open.
   b. Airflow sensor: Recalibrate to read zero when supply air fan serving the zone is proven off or the damper is known to be fully closed. If the fan has not shut off in 40 hours (e.g. for 24/7 fans), temporarily drive the damper fully closed, re-zero the airflow sensor, then release the damper to normal control.] *(Note 3.8)*
7. Alarms
   a. Low airflow.
      i. If the measured airflow is less than 70% of setpoint for 5 minutes, generate a Level 3 alarm.
      ii. If the measured airflow is less than 50% of setpoint for 5 minutes, generate a Level 2 alarm.
   b. Low supply air temperature.
      i. If the supply air temperature is 5°F less than setpoint for 5 minutes, generate a Level 3 alarm.
      ii. If the supply air temperature is 10°F less than setpoint for 5 minutes, generate a Level 2 alarm.
   c. For floating damper actuators, the zone controller will count the total number of damper movements (open or close) for each damper during each 24 hour period. If the total number of movements for any damper in a period exceeds 700, generate a level 3 alarm indicating a control stability problem and excess damper motor wear.

D. Isolation Areas *(Note 3.9)*
1. Each system shall be broken into separate “Isolation Areas” composed of a collection of one or more zones served by the air handling system.
2. Individual Isolation Areas shall be as follows: *(Note 3.10)*
   a. Each floor. *(Note 3.11)*
   b. All 24/7 areas, such as computer rooms. *(Note 3.12)*
   c. *(Note 3.13)*
3. Each Isolation Area shall have separate occupancy schedules and operating modes from other Isolation Areas served by the air handling system. All zones in the Isolation Area shall be in the same operating mode.
4. Each Isolation Area shall be a separate “zone” with respect to the occupant override system. Occupant interface software shall be programmed to allow occupants to override normal schedule programming to operate the system during off hours for a period set by the occupant, within software time limits adjustable by the operator.
5. Provide a post-construction purge timer in software for each isolation zone. This timer, when non-zero, simply causes the area to operate in the occupied mode regardless of time schedule to purge pollutants that are generated by

construction activities and off-gassing from new building materials. The timer automatically steps down with time. (For instance, setting the counter to 20 would cause the system to operate in purge for 20 days.) This timer shall be set to a 20 day purge period directly after initial construction and also in the future by building engineers after any significant tenant improvement work has been done.

6. Isolation Area Operating Modes: Each Isolation Area shall have the following modes:
   a. Normal (Occupied) mode: An Isolation Area is in the occupied mode when any of the following is true:
      i. The time of day is between the Isolation Area's scheduled occupied start and stop times. Note: Occupied start time shall be scheduled to be 1 hour before the building is expected to be occupied (for Title 24 required purge).
      ii. The schedules have been overridden by the web-based Occupant Interface override system
      iii. Any zone local override timer (initiated by local override button) is nonzero.
      iv. The post-construction purge timer is non-zero.
   b. Warm-up mode. Warm-up start time shall be determined based on the zone in the Isolation Area whose space temperature is furthest below its occupied heating temperature setpoint (excluding zones whose window switches indicate the window is open), the outside air temperature, and a building mass/capacity factor. This factor shall be manually adjusted or self-tuned by the program based on internal trending so that all zones in the Isolation Area are brought up to their occupied setpoint by the scheduled occupied start hour. The tuning period mode shall be turned on or off by a software switch (to allow tuning to be stopped after the system has been trained). Warm-up mode shall start no earlier than 3 hours before the scheduled occupied start hour and shall end at the scheduled occupied start hour.
   c. Cool-down mode. Cool-down shall be determined based on the zone in the Isolation Area whose space temperature is furthest above its occupied cooling temperature setpoint (excluding zones whose window switches indicate the window is open), the outside air temperature, and a building mass/capacity factor. This factor shall be manually adjusted or self-tuned by the program based on internal trending so that all zones in the Isolation Area are brought down to their occupied setpoint by the scheduled occupied start hour. The tuning period mode shall be turned on or off by a software switch (to allow tuning to be stopped after the system has been trained). Cool-down mode shall start no earlier than 3 hours before the scheduled occupied start hour and shall end at the scheduled occupied start hour.
   d. Setback mode. During other than normal mode, and warm-up mode, if any zone in the Isolation Area falls 2°F below its active unoccupied setback setpoint, until all spaces in the Isolation Area are above their active setback setpoints.
   e. Setup mode. During other than normal mode, warm-up mode, and setback mode, if any zone in the isolation rises 2°F above its active unoccupied setup setpoint until all spaces in the Isolation Area are below their active setup

setpoints.

f. Unoccupied mode. When the Isolation Area is not in any other mode.

7. Air Handling Unit System Modes:

   a. AHU system modes are the same as the mode of the Isolation Areas served by the system. When Isolation Areas served by an air handling system are in different modes, the following hierarchy applies (highest one sets AHU mode):

      i. Occupied mode

      ii. Cool-down mode

      iii. Setup mode

      iv. Warm-up mode

      v. Setback mode

      vi. Unoccupied mode

E. VAV Air Handling System *(Note 3.14)*

1. Supply fan control.

   a. AH fan start/stop:

      i. For systems with VAV Reheat boxes on perimeter zones: AH unit fan shall run when system is in any mode other than Unoccupied Mode.

      ii. For systems with fan-powered boxes on perimeter zones: AH unit fan shall run when system is in the Cool-down Mode, Setup Mode, or Occupied Mode.

      iii. Fan speed shall be controlled to rise very slowly to prevent high pressure trips in case all VAV boxes are closed (they should close during unoccupied periods) or in case fire/smoke dampers are closed (in some FSD designs, the dampers are interlocked to the fan status rather than being controlled by smoke detectors). This can be done by configuring the VFD ramp rate or controlling ramp rate in EMCS software.

      iv. Fan VFDs shall be hard-wire interlocked through high discharge and low mixed air static pressure safety relays mounted in the control panel in each fan room area. The relay energizes when high-limit DP switches sense pressure above 3.0" (adj.) at the fan discharge or –1.0” (adj.) in the mixed air plenum relative to the return air plenum, locking out the fans until they are reset by the reset DO point or a push-button on the panel face. A pilot light on the panel face indicates static pressure safety lockout is in effect.

   b. Static pressure setpoint reset.

      i. Reset loop is disabled and output set to zero when fan is commanded off and enabled when fan is commanded on.

      ii. Setpoint shall be determined within the range of 0.5" to MaxP by a direct-acting control loop whose control point is the damper position of the most open VAV damper and whose setpoint is 90% open. In other words the static setpoint will be reset to maintain the VAV box requiring the most static pressure at 90% open.

iii. MaxP shall be determined by the air balancer in conjunction with the control contractor as that required to provide design airflow in all boxes downstream of the duct static pressure sensor. See 15950 Testing, Adjusting and Balancing. *(Note 3.15)*

iv. Demand limit setpoint adjustment. Static pressure setpoint reset shall be locked out upon demand limit requests from the associated Isolation Area. Current setpoint shall be increased as follows.

a) At Demand Limit Level 1, decrease current setpoint by 0.1”.

b) At Demand Limit Level 2, decrease current setpoint by 0.3”.

c) At Demand Limit Level 3, decrease current setpoint by 0.5”.

c. Supply fan speed is controlled to maintain duct static pressure at setpoint when the fan is proven on. Minimum speed is 10% (for motor cooling). Where the Isolation Areas served by the system are small, provide multiple sets of PID gains that are used in the PID loop as a function of a load indicator (e.g. supply fan airflow rate, the area of the Isolation Areas that are occupied, etc.).

2. Minimum outdoor air control *(Note 3.16)*

a. See zone CO_2 controls under VAV zone controls.

b. Open minimum outdoor air damper when the supply air fan is proven on and the system is not in warm-up, cool-down, setup, or setback mode. Damper shall be closed otherwise.

c. DP Setpoint (MinDP):

i. With supply fan at design airflow rate, determine in conjunction with air balancer the absolute minimum outdoor air damper differential pressure, AbsMinDP, that provides an outdoor air rate equal to the sum of the absolute minimum outdoor air rates of all zones served by the system which are:

a) For zones with CO_2 controls: 0.15 CFM per square foot of occupied zone area.

b) For zones without CO_2 controls: the greater of 0.15 CFM per square foot of occupied area or 15 CFM per person.

ii. With supply fan at design airflow rate, determine in conjunction with air balancer the design minimum outdoor air damper differential pressure, DesMinDP, that provides the design minimum outdoor air rate as listed on drawings. *(Note 3.17)*

iii. The minimum outdoor air (MinDP) setpoint shall be reset based on the highest zone CO_2 PID loop signal from AbsMinDP at 50% signal to DesMinDP at 100% signal.

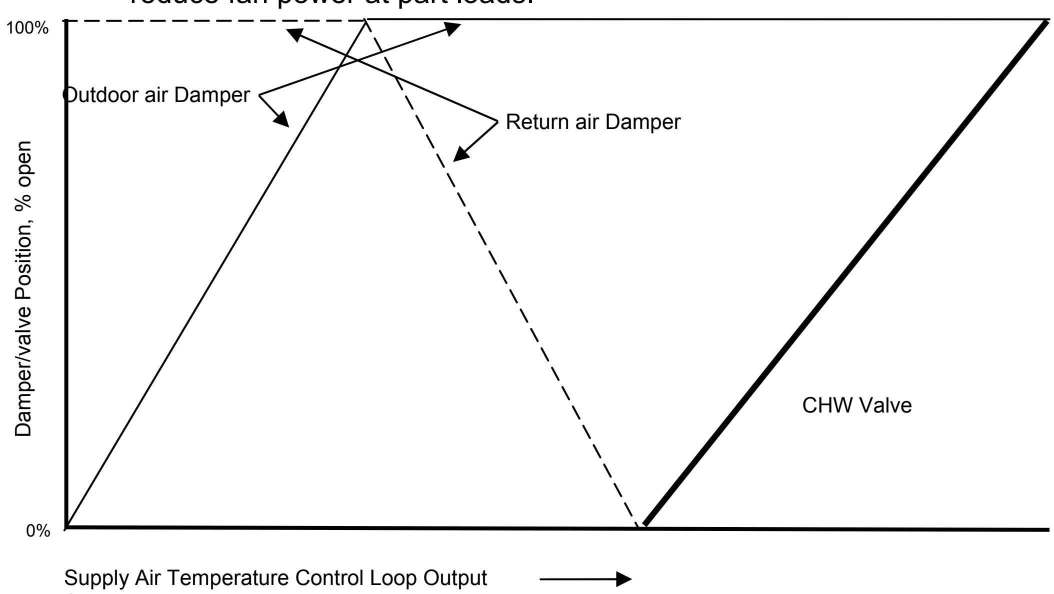
iv. See below for return air damper control of mixed air plenum pressure. *(Note 3.18)*

d. Minimum outdoor air rate static pressure setpoint MinDPsp shall be determined by the equation below: (This is to prevent excess outdoor air from being supplied during off-hour, partial occupancy operation.)

$$MinDPsp = MinDP\left[\frac{A_{active}}{A_{total}}\right]^2$$

where active is area of active Isolation Areas and total is the overall floor area served by the system. The Contractor shall calculate the floor area of Isolation Areas from drawings.

3. Supply air temperature control. *(Note 3.19)*
   a. Cooling supply air temperature control loop is enabled when the supply air fan is proven on and the system is not in warm-up or setback mode, and disabled and output set to zero otherwise. [When loop is disabled, slowly reduce loop output to zero to prevent sudden pressure changes in the CHW flow distribution system.] *(Note 3.20)*
   b. Supply air temperature setpoint:
      i. During occupied mode: Setpoint is reset from T-min (53°F) when the outdoor air temperature is 60°F and above, proportionally up to T-max when the outdoor air temperature is 55°F and below. T-max shall range from 55°F to 65°F and shall be the output of a slow reverse-acting PID loop that maintains the Cooling Loop of the zone served by the system with the highest Cooling Loop at a setpoint of 90%. *(Note 3.21)*
      ii. During setup or cool-down modes, the setpoint shall be T-min
   c. Supply air temperature shall be controlled to setpoint using a PID loop whose output is mapped to sequence the economizer dampers and chilled water valve as shown in the diagram below. Outdoor air and return air dampers are sequenced rather than complementary (as per most standard sequences) to reduce fan power at part loads.



4. Economizer lockout: The normal sequencing of the economizer dampers (above) shall be overridden and economizer outdoor air dampers shall be shut whenever the outdoor air temperature is greater than return air temperature. Provide deadband to prevent short-cycling between modes. When economizer is first disabled and outdoor air damper is shut, return air damper shall be set to 100% open. After 3 minute time delay, return air damper shall be released for minimum outdoor air control (described below).] *(Note 3.22)*
5. Return air dampers.

a. [When the economizer outdoor air damper signal is less than 3% until it rises to 8%, the RA damper signal is modulated to maintain differential pressure across the outdoor air damper at setpoint, MinDPsp, determined above.] *(Note 3.23)*

b. [When the economizer is locked out due to warm weather, the RA damper signal is modulated to maintain differential pressure across the outdoor air damper at setpoint, MinDPsp, determined above.] *(Note 3.24)*

6. Return fans:

a. Fan VFDs shall be hard-wire interlocked through high discharge static pressure safety relay mounted in the control panel in each fan room area. The relay energizes when high-limit DP switch senses pressure above 1.0" (adj.) at the fan discharge relative to atmosphere, locking out the fans until they are reset by the reset DO point or a push-button on the panel face. A pilot light on the panel face indicates static pressure safety lockout is in effect.

b. Return fan operates whenever associated supply fan is proven on.

c. Return fan speed shall be controlled to maintain return fan discharge static pressure at setpoint. The setpoint shall be determined in conjunction with the air balancer as the larger of the following:

i. That required to deliver the design return air volume across the return air damper when the supply air fan is at design airflow and on minimum outdoor air.

ii. That required to exhaust enough air to maintain space pressure at setpoint (0.05") when the supply air fan is at design airflow and on 100% outdoor air.

d. [Relief/exhaust dampers shall only be enabled when the return fan is proven on and the associated economizer outdoor air damper is open greater than 5% above the minimum position signal, and disabled when the damper is at the minimum signal or the return fan is proven off.] (*Note 3.25)* [on and the minimum outdoor air damper is open. The relief/exhaust dampers shall be closed when disabled.] *(Note 3.26)*

e. Building static pressure shall be time averaged with a sliding 5-minute window (to damper fluctuations). The averaged value shall be that displayed and used for control.

f. When the relief/exhaust dampers are enabled, they shall be controlled by a PID loop that maintains the building pressure at a setpoint of 0.05". (Due the potential for interaction between the building pressurization and return fan control loops, extra care must be taken in selecting the PID gains. To prevent excessive control loop interaction, the closed loop response time of the building pressurization loop should not exceed 1/5 the closed loop response time of the return fan control loop. This can be accomplished by decreasing the gain of the building pressurization controller.) *(Note 3.27)*

7. Alarms

a. Maintenance interval alarm when fan has operated for more than 1500 hours: Level 5. Reset interval counter when alarm is acknowledged.

b. Fan alarm is indicated by the status input being different from the output command after a period of 60 seconds after a change in output status.

i. Commanded on, status off: Level 2.

ii. Commanded off, status on: Level 4.

c. Filter pressure drop exceeds alarm limit. Level 5. The alarm limit shall vary with fan speed as follows:

$$DP_x = DP_{100}(x)^{1.4}$$

where DP_{100} is the high limit pressure drop at design cfm (determine limit from filter manufacturer) and DP_x is the high limit at blade angle signal x (expressed as a fraction of full signal). For instance, the setpoint at 50% of full blade angle would be $(.5)^{1.4}$ or 38% of the design high limit pressure drop.

d. High supply air temperature (> 2°F above setpoint) off cooling coils when coil control loop is active for longer than 5 minutes. Level 3.

e. While cooling valve is closed, if the temperature drop across the cooling coil exceeds 2°F continuously for 30 minutes; or if the discharge temperature is more than 5°F below setpoint for more than 30 minutes continuously: Level 4 indicating possibly leaking valve.

f. If mixed air temperature is less than 40°F or greater than 85°F; OR if the outside air temperature is above the supply air temperature setpoint and the economizer is enabled and the mixed air temperature is more than 2°F different from the outside air temperature for more than 30 minutes continuously; OR if the outdoor air temperature is more than 5°F below the supply air temperature setpoint and the chilled water valve is open (or compressors are on): Level 4 indicating economizer damper control problems.

g. Low static pressure (< 0.2” below setpoint) when fan control loop is active for longer than 5 minutes. Level 2.

h. Outdoor airflow less than setpoint for 10 minutes: Level 2.

END OF SECTION

SECTION 17058 - EMCS POINTS AND SEQUENCE OF OPERATION - NOTES

NOTE 1:

1.1 This is a subsection of a much larger specification for EMCS points and sequences of operation. The subsections included address how points should be identified and control sequences for one common system type.

NOTE 2:

2.1 Specifying trending setup for both commissioning and normal operation is required or it will simply not be done − on many systems setting up trends can be very time consuming and it will not be done unless bid documents specifically call it out.

2.2 Many specs require field calibration of all sensors. This is not usually necessary, and in most cases will simply not be done. It is better to spend the money for calibration of sensors that really matter to performance and allow standard factory calibration of most sensors where absolute accuracy is not very significant. This section defines three ways to calibrate sensors, including the use of drywell baths for sensors that require extremely accurate calibration such as chilled water temperature sensors used for ΔT and load calculations.

2.3 The following tables are for a typical VAV system. Considerable editing is required to customize this to the building.

NOTE 3:

3.1 The following sequences are for "standard" control system types. Considerable editing is required to customize this to the building. The intent is to standardize on points and control sequences to the greatest extent possible in order to reduce commissioning time and maintenance problems.
These sequences should not be moved to the drawings themselves due to their length and to retain the ease of editing them in this format. This format also makes it easier to send to controls contractor for their use. They will eventually be on the contractor's as built "record set" drawing and on the Operator Workstation, so it is not important for "posterity" that sequences be on plans.

3.2 System hierarchy: Air handling systems serve a collection of Isolation Areas which in turn are a collection of zones. Each Isolation Area can have a different occupancy schedule, allowing the system to serve only a small number of spaces for off-hour energy savings. For small systems and for single zone systems, there may be only one Isolation Area but the basic logic still applies.

3.3 Note that with traditional VAV reheat control, Vheat-max is usually called the zone Minimum airflow rate. It must be changed in schedules to Heating Maximum for the sequence specified here to avoid confusion.

3.4 It is best if VAV box schedules reflect this value since control contractor will not be able to calculate it readily. In determining the minimum, do not be concerned about the minimum setpoint allowed by the controls; that limit is taken into account below.

3.5 It is best if VAV box schedules reflect this value since control contractor will not be able to calculate it readily. In determining the minimum, do not be concerned about the minimum setpoint allowed by the controls; that limit is taken into account below. Note on zones where 15 cfm/person results in a minimum airflow setting larger than 50% of the cooling maximum, a series fan-powered box should be considered to minimize reheat energy waste and to avoid having to run the boiler even in hot weather. 3.6 The minimum cannot be reduced to zero due to Title 24 requirement to ventilate spaces when they are "expected" to be occupied. Without this minimum rate, 0.15 cfm/ft2, pollutants off-gassing from furnishings and construction materials can build up causing poor indoor air quality when the space is reoccupied.

3.7 Higher temperatures tend to cause air to stratify and bypass into the return air.

3.8 Delete for critical rooms that cannot handle temporary air shut off such as labs.

3.9 This section defines the ability of a central system to serve sub-parts called isolation areas per Title 24. This is an often overlooked code requirement.

3.10 Create this subsection for each system:

3.11 Where required, provide more than one Isolation Area per floor so that all Isolation Areas are smaller than 25,000 ft2 as required by Title 24)

3.12 Delete if no such area is served by system.

3.13 Add areas as required. Make sure they are not so small that fan or cooling stability problems arise.

3.14 Typical of VAV system with return fan.

3.15 MaxP is provided to ensure some "rogue" zone does not cause static pressure rise above the maximum that should be required.

3.16 This sequence is written assuming minimum outdoor air will be maintained by differential pressure from the mixed air plenum to ambient.

For systems two-position minimum outdoor air damper and CO2 control. The minimum outdoor air damper must be sized for the absolute minimum outdoor air rates since the damper will be fully open (two position) and outdoor air can only be increased, not decreased. If there is a very large difference between absolute minimum and the design outdoor air flow rates, then another way to limit minimum outdoor air should be considered as this scheme will have a significant increase in fan energy when trying to draw large amounts of outdoor air through a small damper.

3.17 Make sure design minimum outdoor air rate is indicated in schedules or plans.

3.18 This adjustment is required to prevent over-ventilation when system is serving only a few isolation areas.

3.19 This section assumes there is no heating coil

3.20 This is required only for primary-only chilled water systems but a good idea on any system to avoid DP fluctuations.

3.21 The intent here is to keep supply air temperature low when zones are unlikely to need heating to reduce fan energy. When it is cold outside, supply air temperature is allowed to ride to reduce reheat energy losses and overcooling of zones without reheat coils.

N O T E S

REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY

3.22 Applicable only when minimum outdoor air is determined by a DP sensor across the minimum outdoor air damper.

3.23 Applicable only when there is a heating coil at the AHU or if every zone has a reheat coil. Delete if there is no heating coil in cold climates (due to possible coil freezing) or if there are cooling-only zones with non-zero minimum setpoints (due to overcooling).

3.24 Applicable only when there is no heating coil and not every zone has a reheat coil. Not applicable when the system is operating at minimum outdoor air in cold weather to prevent overcooling interior spaces. Under those conditions, outdoor air rates may fall below minimum, but infiltration rates will increase due to stack effect.

3.25 Applicable when minimum outdoor air will not over-pressurize building, typical of offices. This is to ensure relief fans do not run inadvertently due to bad building static signal.

3.26 Applicable when minimum outdoor air is high enough to overpressurize the building even with minimum outdoor air.

3.27 If there are several air handlers serving a common atmosphere, control all relief fans together to avoid hunting.

REFERENCES

SECTION 17959 - EMCS SYSTEM COMMISSIONING

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Provide the following:
   1. EMCS and equipment testing and start-up
   2. Validation of proper and thorough installation of EMCS and equipment
   3. Functional testing of control systems
   4. Demonstration testing of control systems
   5. Documentation of tests, procedures, and installations
   6. Coordination of EMCS training
   7. Documentation of EMCS Operation and Maintenance materials

B. Refer to Section 17050 for general requirements.

1.2 RELATED WORK AND REQUIREMENTS

A. Section 17050 Energy Management and Control System (EMCS) − General

B. Section 17051 EMCS Basic Materials and Devices

C. Section 17052 EMCS Operator Interfaces

D. Section 17053 EMCS Field Panels

E. Section 17054 EMCS Communication Devices

F. Section 17055 EMCS Software and Programming

G. Section 17058 EMCS Points and Sequence of Operation

H. Section 01810 Commissioning

I. Section 15950 Testing, Adjusting, and Balancing

J. Section 15970 Mechanical Commissioning

K. Section 16080 Electrical Commissioning

1.3 COORDINATION

A. Assist Commissioning Coordinator as specified in Section 01810 Commissioning, including attending commissioning meetings.

B. Testing, Adjusting, and Balancing
   1. Coordinate with TAB contractors in test and balance work as specified in Section 15950 Testing, Adjusting, and Balancing. A significant number of balancing procedures require the EMCS to be operational and require Contractor time to assist the TAB contractor in their work.
   2. Terminal unit calibration:
      a. Provide software and/or portable devices for terminal unit calibration per Section 17055.
      b. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator’s terminal shall be either

at the sensor or at the terminal box, or the wireless router system specified under Section 17054 shall be operational.

C. Coordinate with Division 15 and 16 contractors in the performance of pre-functional, functional, and post-occupancy tests as specified in Section 15970 Mechanical Commissioning and Section 16080 Electrical Commissioning.

1.4 SEQUENCING

A. The following list outlines the general sequence of events for submittals and commissioning:

1. Submit Submittal Package 0 (Qualifications) and receive approval.
2. Submit Submittal Package 1 (Hardware and Shop Drawings) and receive approval.
3. Initiate installation of EMCS hardware, devices and wiring.
4. Develop point database and application software.
5. Simulate sequencing and debug programming off-line to the extent practical.
6. Submit Submittal Package 2 (Programming and Graphics) and receive approval.
7. Complete installation of EMCS hardware, devices and wiring.
8. Install point database and application software in field panels.
9. Submit Submittal Package 3 (Functional Testing) and receive approval.
10. Perform EMCS Pre-functional Tests (start up, calibration and tuning) and submit Pre-functional Tests for approval.
11. Field test application programs prior to functional testing.
12. Receive EMCS Pre-functional Test Report approval and approval to schedule Functional Tests.
13. Perform and record functional tests and submit Functional Test Report for approval.
14. Assist TAB contractor in TAB tests and determining setpoints as specified in Section 15950.
15. Submit Package 4 (Training Materials) and receive approval.
16. Receive EMCS Functional Test Report approval and approval to schedule Demonstration Tests.
17. Perform Demonstration Tests to Commissioning Coordinator and Owner Representatives and submit Demonstration Test Report.
18. Receive acceptance of Demonstration Tests.
19. Train Owner personnel on EMCS operation and maintenance.
20. Substantial Completion.
21. Prepare and initiate commissioning Trend Logs.
22. Submit Trend Logs in format specified for review and approval.
23. Receive approval of successful Trend Log tests, or retest as required.
24. Complete all items in Completion Requirements per Section 17050.
25. Provide administration level password access to the Owner.
26. Final Acceptance.
27. Begin Warranty Period.

28. Prepare and initiate post-occupancy Trend Logs.
29. After 6 months of operation, submit Trend Logs in format specified for review and approval.
30. Receive approval of successful Trend Log tests, or retest as required.
31. Two months prior to end of Warranty Period, submit Trend Logs in format specified for review and approval.
32. Receive approval of successful Trend Log tests, or retest as required.
33. Revise and submit record documents and O&M Manuals.
34. Update all software as specified.
35. End of Warranty Period.

1.5 FUNCTIONAL TEST DOCUMENTATION

A. Pre-functional Tests
   1. Prepare forms to document the proper startup of the EMCS.
   2. All equipment shall be included on test forms including but not limited to:
      a. Digital outputs: proper installation, normal position, response to command at CU
      b. Digital inputs: proper installation, device test, response at CU
      c. Analog outputs: proper installation of devices, verification of maximum and minimum stroke
      d. Analog inputs: proper installation of sensors, calibration
      e. Wiring connections and other electrical issues
      f. Panels
      g. Alarms and safeties
      h. Loop tuning
      i. Network traffic
   3. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
   4. Submit forms for approval in Submittal Package 3.
   5. Complete work, document results on forms, and submit for approval as Pre-Functional Test Report.

B. Functional Tests
   1. [Owner Representatives (Design Engineers) will prepare functional testing forms after Submittal Package 2 has been reviewed and approved. Tests will be designed to test all sequences in a formal manner with simulations and expected outcomes.
   2. Contractor will review tests and recommend changes that will improve ease of testing or avoid possible system damage, etc.] *(Option 1)*
   3. [Contractor shall prepare functional testing forms to test all sequences in a formal manner. Test forms shall include at a minimum: a column indicating the tests and simulations to be performed, the expected outcomes, the actual outcome, and check box indicating whether the system passed or failed.
   4. All control sequences shall be functionally tested. For systems that use identical control logic (e.g. VAV boxes, identical air handlers), only one subsystem need

be tested; any changes to programming resulting from tests shall be made to all identical applications.] *(Option 2)*

5. Each form shall have a header or footer where the technician performing the test can indicate his/her name and the date of the test.
6. Submit forms for approval in Submittal Package 3.
7. Complete work, document results on forms, and submit for approval as Functional Test Report.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. Instrumentation required to verify readings, calibrate sensors, and test the system and equipment performance shall be provided by Contractor.

B. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is ±0.5% accurate, test equipment shall be ±0.25% accurate over same range).

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL TESTS

A. General

1. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
2. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
3. Verify integrity/safety of all electrical connections.
4. Verify that shielded cables are grounded only at one end.
5. Verify that all sensor locations are as indicated on drawings and are away from causes of erratic operation.
6. Ensure that minimum speed settings programmed into variable speed drive are at or below the minimum speed settings in control sequences.

B. Digital Outputs

1. Verify that all digital output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.

C. Digital Inputs

1. Adjust setpoints, where applicable.
   a. For current switches used as status on fans, adjust current setpoint so that fan status is "off" when fan discharge damper (if present) is fully closed and when belt is broken (temporarily remove belt).
   b. For current switches used as status on pumps, adjust current setpoint so that pump status is "off" when pump is dead-headed (temporarily close discharge

valve).

c. For differential pressure sensors on pumps and fans, set so that status is on when pump operating with all valves open (out on its curve).

D. Analog Outputs

1. Verify start and span are correct and control action is correct.
2. Check all control valves and automatic dampers to ensure proper action and closure. Make any necessary adjustments to valve stem and damper blade travel.
3. Check all normal positions of actuators with spring return.
4. For outputs to reset other manufacturer's devices (for example, chiller setpoint) and for feedback from them, calibrate ranges to establish proper parameters.
5. Test and document actual spring range of pneumatic actuators from full open to full close and reflect this in pneumatic output ranges. *(Note 3.1)*

E. Analog Input Calibration

1. Sensors shall be calibrated as specified on the points list. Calibration methods shall be one of the following:
   a. Factory: Calibration by factory, to standard factory specifications. Field calibration is not required.
   b. Handheld: Field calibrate using a handheld device with accuracy meeting the requirements of Paragraph 2.1.
   c. Drywell Bath: Field calibrate using a 2-point procedure, using a drywell calibrator block constructed for that purpose, or an ice bath with a reference standard.
2. The calibrating parameters in software (e.g. slope and intercept) shall be adjusted as required. A calibration log shall be kept and initialed by the technician showing date and time, sensor and hand-held readings, and calibration constant adjustments and included in the Pre-functional Test Report.
3. Inaccurate sensors must be replaced if calibration is not possible.

F. Alarms and Interlocks:

1. A log shall be kept and initialed by the technician showing date and time, alarm/interlock description, action taken to initiate the alarm/interlock, and resulting action, and included in the Pre-functional Test Report.
2. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
3. Coordinate with Division 16 to test fire and life safety systems alarm contacts.
4. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
5. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

G. Tuning

1. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the Pre-functional Test Report. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any upset (for which the

system has the capability to respond) in the control loop, tolerances shall be maintained (exceptions noted):

Controlled Variable	**Control Accuracy**
Duct Pressure	±0.1" w.g.
Building and relief plenum	±0.01" w.g.
Airflow	±10%
Laboratory fume hood and make-up airflow	See 15995
Space Temperature	±1.5ºF
Chilled Water Temperature	±1ºF
Hot Water Temperature	±3ºF
Duct Temperature	±2ºF
Water Differential Pressure	±1.5 psi
Others	±2 times reported accuracy

H. Interface and Control Panels:

1. Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
2. Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
3. Check power supplies for proper voltage ranges and loading.
4. Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
5. Check for adequate signal strength on communication networks.
6. Check for standalone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
7. Ensure that buffered and/or volatile information is held through power outage.
8. With all system and communications operating normally, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
9. Check for adequate grounding of all DDC panels and devices.

I. Operator Interfaces:

1. Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
2. Verify that the alarm printing, logging, paging, emailing etc. is functional and per requirements.

J. Trending/Network Traffic Test. Perform this test to verify that system has been design adequately to simultaneously capture trends and allow proper operation of the control system.

1. The test shall be performed after the verification trends (see paragraph 3.5A) have been set up and are operational.
2. Test 1:

a. Randomly select a device whose failure will generate a Level 1 or 2 alarm and manually shut it off. The status points for the device must indicate the change of state of the device at the Operator Workstation within 5 seconds.

b. The test shall be repeated for four devices in each building.

3. Test 2:

a. A clock signal from a field controller randomly selected will be sent as a programmable point to up to 3 BCs. The clock signal stored in BCs shall be sampled with the rest of the trend data. The system shall be considered acceptable if these clock signals are no more than 2 seconds off of the system clock as sampled concurrently during data collection.

4. If the system fails any test, the system architecture shall be revised as required (e.g. more trend memory, more controllers with trend storage capability, network repeaters to allow an increase in network speed, etc.) followed by additional tests.

3.2 TAB TESTS

A. Setpoint Determination

1. Assist the TAB contractor in determining fan and pump differential pressure setpoints, outdoor air damper minimum positions and DP setpoints, etc. as indicated in Section 15950 Testing, Adjusting and Balancing.

B. Coil Valve Leak Check

1. Coordinate test procedures with those outlined in Section 15950 Testing, Adjusting and Balancing along with TAB contractor.

2. Test conditions for each hydronic system:

a. Tests shall be done when central plant cooling and heating systems are operational.

b. Close all control valves

c. Start all fans associated with control valves

d. Open bridge connection control valve.

e. Start both pumps.

f. Observe flow meter. If reading changes after pumps start, there is a leaking valve.

g. Observe supply air temperature at each coil after test starts.

h. Should any supply air temperature rise, close the isolation valves to the coil to see if temperature changes. If so, this validates the valve is not fully closing.

i. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

3.3 FUNCTIONAL TESTS

A. Test schedule shall be coordinated with the Commissioning Coordinator.

B. Tests may be witnessed by a Owner Representative at the Owner's option.

C. All approved Functional Tests shall be conducted by the EMCS Contractor with results confirmed and signed by the Contractor's start-up technician.

D. Test documentation shall be submitted to the Owner for review and approval.

3.4 DEMONSTRATION TEST

A. Demonstration tests consist of a small representative sample of functional tests and systems randomly selected by the Owner. Tests will be designed to occur over no longer than [] days. *(Note 3.2)*

B. Schedule the demonstration with the Owner's representative 1 week in advance. Demonstration shall not be scheduled until the Functional Test Report has been approved.

C. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor-supplied personnel shall be those who conducted the Functional tests or who are otherwise competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems.

D. The system will be demonstrated following procedures that are the same or similar to those used in the Pre-Functional and Functional Tests. The Owner's representative will supply the test forms at the site at the start of the tests.

E. Contractor shall conduct tests as directed by and in the presence of the Owner's representative and complete test forms. Completed forms shall be submitted as the Demonstration Test Report to the Owner and Commissioning Coordinator after tests are complete.

F. Demonstration Tests shall be successfully completed and approved prior to Substantial Completion.

3.5 TREND LOG TESTS

A. Commissioning (Post Construction) Trend Test

1. Trend logging shall not commence until Demonstration Tests are successfully completed.
2. Contractor shall configure points to trend as indicated in the Commissioning Trend column listed in Section 17055 points list with the following qualifications.
   a. For equipment of identical function, such as VAV zones and AHUs with identical components and control sequences, only a sample of such equipment need be trended. The sampling shall be 10% of the identical components, but no more than 10 and no less than three. Review with Owner representative before setting up trends.
      i. Where zone data (e.g. damper or valve position, control loop signal) is used for reset of the AHU/pump system serving the zone, the zone tag (name) and zone data (e.g. damper or valve position) shall be trended. *(Note 3.3)*
   b. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend period and the same time intervals so that data may be easily plotted using a spreadsheet.
3. Trends shall be uploaded to the Trend Historian Server in data format specified in Section 17055.
4. Trend logs of all points indicated above shall be collected for a ___week Trend Period. *(Note 3.4)*
5. At the completion of the Trend Period, data shall be reviewed by the Contractor

to ensure that the system is operating properly. If so, data shall be submitted to the Owner in an electronic format agreed to by the Owner and Contractor (e.g. CD-ROM or via direct access to the Operator Workstation via the internet).

6. Data will be analyzed over approximately a two- to three-week period by a Owner representative.
7. The system shall be accepted only if the trend review indicates proper system operation without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. If any but very minor glitches are indicated in the trends, steps 4 to 6 above shall be repeated for the same Trend Period until there is a complete Trend Period of error free operation.

B. Post Occupancy Trend Tests

1. After successfully completing the Commissioning Trend Tests, the Contractor shall configure all points to trend as indicated in the Continuous Trend column listed in Section 17055 points list.
2. Archive trends up to the Operator Workstation without overwriting stored data for the entire Warranty Period.
3. Data will be reviewed by a Owner representative at the following intervals:
   a. Approximately 6 months after system acceptance.
   b. Approximately 2 months prior to the end of the Warranty Period.

3.6 REMEDIAL WORK

A. Remedial work identified by site reviews, review of submittals, demonstration test, trend reviews, etc. shall be performed to the satisfaction of the Owner's Representative, at no additional cost to the Owner.

B. Contractor shall compensate Owner and Owner's representative for costs required to repeat demonstration tests or trend reviews. See Section 10810.

3.7 TRAINING

END OF SECTION

N O T E S

SECTION 17959 - EMCS SYSTEM COMMISSIONING - NOTES

NOTE 3:

3.1 Delete if no pneumatics.

3.2 May want additional test time for complex buildings (e.g. laboratories)

3.3 This data is necessary so that zones that are undersized or otherwise driving the system can be identified for remediation if required. The position of the most open damper/valve is also critical for commissioning the reset sequences.

3.4 Typically 2 but as much as 4 for complex project.

REFERENCES

CONTENTS

CONTENTS 1
DISCLAIMER 2
I. GENERAL 3
II. CHILLER PLANT 5
III. COOLING TOWERS 10
IV. AUXILIARY CONDENSER WATER SYSTEM 14
V. BOILER PLANT 16
VI. UNDERFLOOR AHU 18
VII. BUILDING PRESSURIZATION RELIEF FAN CONTROL 35
VIII. UNDERFLOOR FAN BOXES 38
IX. FIRST FLOOR PARALLEL FAN BOXES 41
X. FIRST FLOOR VAV AHU 45
XI. GARAGE SUPPLY AND EXHAUST 59
XII. TELEPHONE OVERRIDE SYSTEM 61

DISCLAIMER

The authors have tried to make the information in this document as accurate and useful as possible. However, they make no warranty, express or implied, and assume no legal liability for the information in this report. References to specific manufacturers or products are provided for the convenience of the reader and shall not be considered endorsements.

These specifications were prepared as a 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 warranty, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights.

[Please note that these are sample functional testing forms that will require editing for specfic projects]

Heating, Ventilating, And Air Conditioning Systems
Functional Testing

I. GENERAL

A. Pre-requisites

1. All HVAC equipment must be successfully started and tested and balanced before beginning functional testing.
2. All pre-functional testing must be successfully completed before beginning functional testing.
3. Calibration and loop tuning (refer to section 15950) must be successfully completed before any functional testing can begin.
4. All systems should be running according to normal sequence of operations unless commanded otherwise as part of functional testing.

B. Test sequence

1. Functional tests can be performed in any order. For example air handler units can be tested before or after boiler plant. In fact, the tester is encouraged to simultaneously perform tests, as long as they do not interfere with each other. Consult with commissioning agent if there is a question about test interference.

C. Graphing.

1. All required graphs shall be plotted for the duration of the functional test and permanently stored in Excel or similarly accessible electronic format.
2. The x-axis will always be time. Use a primary and secondary y-axis if graphing variables with different engineering units. All variables with the same engineering unit shall plot with the same scale.
3. Maximum time step shall be as specified or "change of value".
4. All graphs shall include exact date and time.
5. Graphs may be split into multiple graphs if each line cannot be clearly identified (e.g. Points on top of each other, or not enough line colors or line types). If graphs are split up, they must have the same x-axis origin and scale.

D. Documentation

1. Functional test results are to be recorded electronically. The tester will fill in the necessary fields in the MS Word document. For each test requiring graphs, the tester will clearly indicate the file name and location of applicable graphs.

2. The "Observed Response" field should be a narrative including date and time of all commands performed and times of system responses as well as reference to applicable graphs. For example: "1/2/02 15:33: CH-1 manually turned off. 15:48 CH-2 observed to come on automatically. See graph xyz.xls, chart 4."

3. The "Pass?" field should be either "Y" if expected response is clearly exhibited, "N" if not clearly exhibited, or "Inc" for incomplete. If "N" or "Inc", please discuss reasons for failure and re-test plans in "Observed Response" or using the insert comment feature.

E. Communication

1. Tester shall review all functional tests before starting and provide feedback to the commissioning agent on any potential problems.

F. Waiting times

1. Many of the functional tests require performing a command, then waiting for a specified period of time, then performing other commands. The waiting times in the tests correspond to the time delays specified in the controls specification. It is acceptable to reduce the time delays in the sequence of operations (for functional testing only) and the waiting times for the functional tests. Any such modifications should be clearly described in the test documentation.

II. CHILLER PLANT

A. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Actual and predicted kW for CH-1 and CH-2. Actual kW for CH-3. Total plant load. Percent error ((actual – predicted)/actual)) for CH-1, CH-2 on secondary axis.
2. Actual kW and chiller status for CH-1, CH-2, and CH-3.
3. Individual chiller supply and return temperature.
4. Condenser water isolation valve position, head pressure and setpoint for CH-1, 2, 3.
5. CHP-1, 2, 3 status and (secondary axis) combined CHP-1, 2, 3, kW, and CH-1, CH-2, CH-3 kW
6. CP-1, 2, 3 status and (secondary axis) combined CP-1, 2, 3, kW, and CH-1, CH-2, CH-3 kW
7. CHW supply temp, CHP-4, 5, 6 % speed
8. CT-1, 2, 3, 4 % speed (0 to 100), CWST, CWRT, CWSTP, secondary axis: CP-1, 2, 3 status
9. CT-1, 2, 3, 4 status, enable water treatment TDS controller, enable sand filter, sand filter status.
10. CT-1, 2, 3, 4 kW, makeup water flow, OA wet bulb, total dissolved solids (if available).
11. Hot gas bypass signal and valve position, total plant load, CH-1 kW.

B. Functional tests:

Test	Expected response	Observed response	Pass?
1. Starting with all chiller plant equipment off: start CHP 4, 5, and 6	CH-1 starts, lead primary CHP starts, CHW isolation valve opens, lead CW pump starts, lead tower cell isolation valve opens		

Test	Expected response	Observed response	Pass?
2. Slowly create a chiller plant load. Load can be created in a number of ways. One way is to command VAV boxes to full flow, and command reheat coil valves to full open.* Another way is to use 100% outside air if the weather is hot. Load should be slowly ramped up from 0 tons to at least 400 tons over a period of at least 4 hours. Load should then be slowly ramped backed down to 0 tons over a period of at least 2 hours. *(*see boiler testing for simultaneous testing of chillers and boilers)*	Chiller staging Ramping up 0 tons: none 0 – 292.5 tons: CH-1 only (except when in hand as noted below) 292.5 – max: CH-1 and CH-2 equally loaded Ramping down Max – 227.5 tons: CH-1 and CH-2 227.5 – 0 tons: CH-2 only 0 tons: none CH-1 and CH-2 predicted and actual efficiency should agree within about 10-20%.		
3. during all chiller testing : observe HGBP at low load			
4. While ramping up: when load reaches at least 50 tons and before load reaches 250 tons (*stage 1*):			
a. Manually turn off CH-1, wait 20 minutes, put it back in auto	Level 2 alarm when CH-1 goes off. CH-2 comes on 15 minutes after CH-1 goes off		
b. Wait 10 minutes. manually turn off CH-2, wait 20 minutes, put it back in auto	Level 2 alarm when CH-2 goes off. CH-3 comes on 15 minutes after CH-2 goes off		
c. Wait 10 minutes, manually turn off CH-3, wait 20 minutes, put it back in auto	Level 2 alarm when CH-3 goes off. CH-1 comes on 15 minutes after CH-3 goes off		

Test	Expected response	Observed response	Pass?
d. Wait 10 minutes, manually turn on CH-3, wait 20 minutes , put it back in auto	Level 4 alarm when CH-3 switched on. CH-1 turns off within 15 minutes of CH-3 coming on.		
e. Reset staging as follows: CH-1, CH-2, CH-3	CH-1 comes on, CH-3 goes off.		
5. During all chiller testing	During stage 1 *(one chiller on*), lead CHW and CW pump shall run. During stage 2 (*two chillers on*), CHW and CW lead and stage 2 pump shall run.		
6. While in stage 1 (*one chiller on*), *(testing of pump lead/lag control)* a. Manually turn off lead CHW pump, wait until system responds, place pump back in auto.	Lag CHW pump starts when lead is turned off. Show the pump in alarm on graphic displays, and enunciate a level 2 alarm as follows: "PUMP FAILURE ALARM. [Pump mark] pump failed to prove operation. Check coupling, motor, power, status point, etc. and reset immediately."		
b. Manually turn off lead CW pump, wait until system responds, place pump back in auto.	Lag CW pump starts when lead is turned off. Show the pump in alarm on graphic displays, and enunciate a level 2 alarm as follows: "PUMP FAILURE ALARM. [Pump mark] pump failed to prove operation. Check coupling, motor, power, status point, etc. and reset immediately."		
c. Manually turn on standby CHW pump, wait until system responds, place pump back in auto.	Lead CHW pump becomes lag and turns off when standby is manually turned on. Alarm.		
d. Manually turn on standby CW pump, wait until system responds, place pump back in auto.	Lead CW pump becomes lag and turns off when standby is manually turned on. Alarm.		

Test	Expected response	Observed response	Pass?
(testing of condenser water head pressure control) e. Override tower controls and turn on all tower cells at 100%. f. Wait until isolation valve has reached a stable state. g. Restore tower controls to auto.	As CWST drops, condenser water isolation valve should begin to close in order to maintain head pressure. Minimum valve signal shall be 5% (to prevent dead-heading pumps). Head pressure setpoint shall be as recommended by the chiller manufacturer. *Observe that controls are stable with no hunting or oscillation.*		
7. While is stage 2 (*two chillers on*), *(testing of pump staging control)* a. Manually turn on standby CHW pump	One of the other 2 CHW pumps turns off. Alarm.		
b. Manually turn on standby CW pump	One of the other 2 CW pumps turns off. Alarm.		
8. Chilled water supply temp. *(testing of chiller setpoint tracking)* a. Command CHW supply setpoint to 60°F	CHWST tracks to 60°F . *(allow adequate time for system to respond)*		
b. Command CHW supply setpoint to 48°F	CHWST should drop to 48°F. *(allow adequate time for system to respond)*		
c. Place CHW supply setpoint back into auto.	CHW supply setpoint should reset to maintain CHP-4,5,6 secondary pumps max speed at 80%. If no secondary CHP is at 80% speed then CHWST must be 60°F.		
d. During AHU testing observe that CHW setpoint is controlled	*Observe that controls are stable with no hunting or oscillation.*		

Test	Expected response	Observed response	Pass?
9. CHP HOA Override (Manual ON) a. With all systems off, manually turn on one secondary CHP pump.	FMCS shall enunciate a level 4 alarm as follows: “PUMP ALARM. [Pump mark] pump is on when it should be off. Check HOA switch at starter or VFD.”		
10. Chiller room high refrigerant concentration alarm. Consult manufacturer's literature for appropriate test procedures.	Level 2 alarm to indicate “caution – probable leak” and Level 1 alarm to indicate “maximum exposure limit”.		

III. COOLING TOWERS

A. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Actual and predicted kW for CH-1 and CH-2. Actual kW for CH-3. Total plant load. Percent error ((actual – predicted)/actual)) for CH-1, CH-2 on secondary axis.
2. Actual kW and chiller status for CH-1, CH-2, and CH-3.
3. Individual chiller supply and return temperature.
4. Condenser water isolation valve position, head pressure and setpoint for CH-1, 2, 3.
5. CHP-1, 2, 3 status and (secondary axis) combined CHP-1, 2, 3, kW, and CH-1, CH-2, CH-3 kW
6. CP-1, 2, 3 status and (secondary axis) combined CP-1, 2, 3, kW, and CH-1, CH-2, CH-3 kW
7. CHW supply temp, CHP-4, 5, 6% speed
8. CT-1, 2, 3, 4 % speed (0 to 100), CWST, CWRT, CWSTP, secondary axis: CP-1, 2, 3 status
9. CT-1, 2, 3, 4 status, enable water treatment TDS controller, enable sand filter, sand filter status.
10. CT-1, 2, 3, 4 kW, makeup water flow, OA wet bulb, total dissolved solids (if available).
11. Hot gas bypass signal and valve position, total plant load, CH-1 kW.

B. Functional tests:

Test	Expected response	Observed response	Pass?
1. Manually cycle through tower staging sequences to verify cell staging order.	Sequence 1: CT-1, CT-3, CT-4, CT-2 Sequence 2: CT-2, CT-4, CT-3, CT-1 Sequence 3: CT-3, CT-1, CT-2, CT-4 Sequence 4: CT-4, CT-2, CT-1, CT-3		
2. Testing of tower sequencing: a. Shutdown all chillers b. Shutdown all auxiliary condenser water pumps (ACP-1, 2, 3, 4) c. Manually set auxiliary CWST to 55°F	All cells shutdown All cell isolation valves closed All primary and auxiliary condenser water pumps off		

Test	Expected response	Observed response	Pass?
d. Start lead closed-circuit auxiliary condenser water pump (ACP-3, 4)	Lead auxiliary condenser water pump open-circuit starts (ACP-1, 2) Lead CT isolation valve opens CWST setpoint should drop to 40°F CT fan speed should rise to maximum of 50%		
e. When one cell is running: 1) Turn on another cell. 2) Wait until system response.	Alarm. Isolation valve for new cell opens. Staging order changes to that which has the manually running cell the first tower. Lead/lag switched locked out until alarm acknowledged. Old cell shuts off. After 20 minutes the isolation valve for the old cell closes.		
3) Restore to cell fan to auto.			
f. Manually set ACWST to 70°F	Second CT cell isolation valves open Second CT fan starts CT fan speed maintain maximum of 50%		
g. When two cells are running: 1) Turn off one of the cells. 2) Wait until system response.	Alarm. Tower staging switches so that failed cell is last in sequence. Cells reconfigure to match new staging. Isolation valve for new cell opens. Lead/lag switched locked out until alarm acknowledged. After 20 minutes the isolation valve for the old cell closes.		
3) Restore to cell fans auto.			

Test	Expected response	Observed response	Pass?
(*if outside conditions allow auxiliary water ACWST to be less than 48°F then*) Release ACWST to normal reading Wait until system has stabilized	CWST setpoint will rise to control ACWST at 48°F CWST setpoint should limit between 40 – 48°F CT fan speed will lower to control CWST Minimum fan speed is 10% If fan speed drops to 10% and CWST is below setpoint for 5 minutes then all CT fans will cycle off for at least 5 minutes and until CWST rises above setpoint.		
(if outside conditions do not allow auxiliary water ACWST to be less than 48°F then) Release ACWST to normal reading Wait until system has stabilized	*(if ACWST is less than 60°F)* Second cell fan will shutdown, after 20 minutes 2nd cell isolation valves will shut. *(if ACWST is greater than 65°F)* 2nd cell will remain online CWST setpoint will lower 40°F to try and control auxiliary condenser ACWST at 48°F CWST setpoint should limit at 40°F CT fan speed will rise to control CWST Maximum fan speed is 50%		
3. Start stage 1 chiller	One chiller condenser water pump starts CWST setpoint becomes 70°F 3rd cell isolation valve opens Maximum fan speed is 65% Minimum fan speed is 10% If fan speed drops to 10% and CWST is below setpoint for 5 minutes then all CT fans will cycle off for at least 5 minutes and until CWST rises above setpoint.		

Test	Expected response	Observed response	Pass?
4. Start stage 2 chiller	2nd chiller condenser water pump starts 4th cell isolation valve opens Maximum fan speed is 100% Minimum fan speed is 10% If fan speed drops to 10% and CWST is below setpoint for 5 minutes then all CT fans will cycle off for at least 5 minutes and until CWST rises above setpoint.		
5. During all testing	Water treatment system and sand filter are enabled when any CW pump is proven on.		
6. During tower testing: Using handheld testing equipment, test the makeup and tower water conductivity and calculate cycles of concentration. Perform test once in morning and once in afternoon for three straight days. At least one cell must be running for at least two hours on each of the three days	Cycles of concentration must be within the design range. See water treatment specialist for the design range.		
7. High TDS in condenser water system alarm. Consult manufacturer's literature for appropriate test procedures.	Level 2 alarm.		

IV. AUXILIARY CONDENSER WATER SYSTEM

A. Graphing. Time step shall be <= 1 minutes or "change of value".

1. CT-1, 2, 3, 4 % speed (0 to 100), CWST, CWRT, CWSTP, secondary axis: CP-1, 2, 3 status
2. CT-1, 2, 3, 4 % speed (0 to 100), CWST, CWRT, CWSTP, secondary axis: ACP-1, 2, 3, 4 status
3. ACP-3, 4 % speed (0 to 100), secondary axis: differential pressure signal, differential pressure setpoint.
4. Open circuit CWST, CWRT, closed circuit CWST, CWRT. Secondary axis: closed circuit CW secondary supply flow

B. Functional Tests:

Test	Expected response	Observed response	Pass?
1. With all underfloor AHUs, CRU-1, 2, all chillers off, and all ACW valves shut: a. Start lead CRU b. When system is stable continue	Lead closed circuit ACP should come on, lead open circuit ACP should come on, tower should come on. CWST should be maintained between 40°F – 48°F Secondary ACP differential pressure should be maintained at setpoint. *(determined by balancing contractor)* *Observe that controls are stable with no hunting or oscillation.*		
c. Open condenser water valve for AC-3 d. When system is stable continue	Secondary ACP differential pressure should be maintained at setpoint. *Observe that controls are stable with no hunting or oscillation.*		
e. Open condenser water valve for AC-4	Secondary ACP differential pressure should be maintained at setpoint. *Observe that controls are stable with no hunting or oscillation.*		

Test	Expected response	Observed response	Pass?
2. Test CWST setpoint: a. Open a CH condenser isolation valve b. Turn on associated pump (CP-1, 2 or 3)	CWST setpoint should reset from between 40°F - 48°F up to 70°F when CP comes on		
c. Turn off the CP d. Return isolation valve and pump to normal	Setpoint should reset between 40°F - 48°F when CP is shut off.		
3. While one primary ACP is running: *(ACP-1, 2)* a. Manually set pump run hours to 199.9 hours *looking for 200 hour switchover*	Lag pump should start and lead pump should shut off 5 minutes later.		
b. Switch off running lead pump	Lag pump becomes the lead and starts. An alarm is generated and lag pump (failed) is locked out		
c. Reset alarm, return pump to auto			
4. While one secondary ACP is running: *(ACP-3, 4)* a. Manually set pump run hours to 199.9 hours *looking for 200 hour switchover*	Lead pump should stop and lag pump start at same time.		
b. Switch off running lead pump c. Reset alarm, return pump to auto	Lag pump becomes the lead and starts. An alarm is generated and lag pump (failed) is locked out		

V.BOILER PLANT

A. Graphing. Time step shall be <= 1 minutes or "change of value".

1. HWP-1, 2 % speed, B-1, 2 isolation valve position, B-1, 2 status, gas consumption
2. HW flow, B-1, 2 supply water temp, return water temp, OAT
3. HWP-1, 2 % speed, secondary axis: differential pressure, differential pressure setpoint,
4. Boiler lead & lag pump lead & lag, boiler and pump status.
5. Predicted and actual boiler plant efficiency, instantaneous HW load (Btu)

B. Functional testing:

Test	Expected response	Observed response	Pass?
1. Boiler staging a. Starting with both boilers off. If OAT > boiler lockout temp, then temporarily increase lockout temperature. Command one isolation zone into warm-up mode and command all HW reheat valves in that zone to 100%. Wait for supply temperature to reach setpoint.	Lead boiler (lowest operating hours) comes on. Isolation valve opens. Lead pump (lowest operating hours) comes on. Differential pressure is maintained at setpoint. Lead boiler supply water temperature is maintained at setpoint (based on OAT).		
b. Command at least one isolation zone on another floor to warm-up mode and open its HW valves to 100%. Wait for supply temperature to reach setpoint.	Lag boiler, isolation valve, and lag pump come on		
c. Manually turn on lag pump *(This tests for manual pump operation and lead/lag switchover. Response will occur when the following section is implemented)* d. Restore pumps to auto when test is complete	Lag boiler shuts off. Lag pump shuts off 5 minutes later. Alarm. Lead pump switches to lag pump. New lag pump shuts off. Isolation valve shuts. Differential pressure is maintained at setpoint.		

Test	Expected response	Observed response	Pass?
e. Command all isolation zones to occupied mode. At least 10% of all reheat valves should be at 100%. Wait 15 minutes	Lead boiler supply water temperature is maintained at setpoint (based on OAT).		
f. Manually turn off lead boiler. g. Restore boiler to auto.	Alarm. Isolation valve shuts. Lag boiler comes on.		
h. Modify timer for low supply temperature to 1min. i. Raise setpoint sufficiently so that HWST < (setpoint – 15°F) for at least 1 min. j. Restore timer and clear alarm.	Alarm. Isolation valve shuts. Lag boiler comes on.		
k. Manually turn off lead pump. l. Restore pump to auto.	Alarm. Lead switches to lag pump. New lead pump starts.		
2. During all functional testing: graph actual vs. Calculated boiler plant efficiency	Actual and predicted efficiency should agree within about 20%.		

VI. UNDERFLOOR AHU

A. Sampling strategy

Test two of three underfloor AHUs.

B. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Isolation zone mode for all isolation zones on that AHU, AHU system mode.
2. Static pressure setpoint, static pressure, position of all control dampers on that AHU (use a single color/line type for all dampers in each isolation zone)
3. SF-A, B speed, static pressure setpoint, static pressure.
4. All 2nd floor space temperatures, heating, and cooling setpoints. (separate colors/line types for interior vs. Perimeter zones)
5. All 2nd floor underfloor static pressures and static pressure setpoints.
6. SAT, OAT, RAT, MAT, supply air dew point, OA dew point, pre-cool OA temp
7. Economizer OA damper position, return air damper position, coil bypass damper position, CHW pump speed, max-p
8. Building pressure, relief fan A, B, C, D, E, F % speed
9. Supply air flow rate, min OA damper flow rate, min OA setpoint, PCC valve position
10. Actual system supply fan efficiency (kW/1000 CFM), predicted system supply fan efficiency.

C. Functional Testing. Copy this table for each AHU tested.

AHU#:__________________	Expected response	Observed response	Pass?
1. System mode a. Command all isolation zones to Unoccupied mode. b. Command floor 2 zone to Setback mode. c. Command floor 6 zone to Warm-up mode. d. Command floor 3 zone to Setup mode. e. Command floor 5 zone to Cool-down mode. f. Command floor 4 zone to Night purge mode. g. Command floor 4 zone to Setback.	System mode: Unoccupied System mode: Setback System mode: Warm-up System mode: Setup System mode: Cool-down System mode: Night purge System mode: Setup		
2. Minimum outside air setpoint a. Command floor 5 zone to occupied mode. b. Command floor 2 zone to occupied. c. Command floor 3 zone to occupied. d. Command floor 4 zone to occupied. e. Command floor 6 zone to occupied.	System mode: Occupied Minimum outdoor air setpoint should increase by the ratio of active (occupied) isolation zones to overall floor area served by the system. Min OA fan and PCC coil should run if economizer locked out or very cold or CWST < OAT + 5°F (refer to controls spec)		

AHU#:__________________	Expected response	Observed response	Pass?
3. Static pressure reset *(all zones)*			
a. Command all isolation zones to occupied mode. Command all occupied control dampers for this AHU to 20%. Wait 5 minutes.	Static pressure should stabilize at 0.15"		
b. Command one control damper to 100%. When static pressure reaches 0.4", command damper to 90%. Wait 5 minutes.	Static pressure should rise to 0.4" and stabilize.		
c. Command same damper to 100%. When static pressure reaches 0.6", command damper to 90%. Wait 5 minutes	Static pressure should rise to 0.6" and stabilize.		
d. Command same damper to 85%. When static pressure reaches 0.2", command damper to 90%.	Static pressure should fall to 0.2" and stabilize.		
(adjust static pressure points equally so maximum is at P-max determined by air balancer)	*Observe that controls are stable with no hunting or oscillation*		

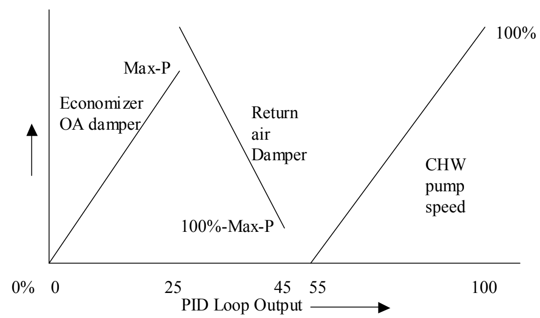
AHU#:__________________	**Expected response**	**Observed response**	**Pass?**
4. Static pressure reset *(3rd and 6th floors zones)*			
a. Command all isolation zones on the 2nd, 4th and 5th floors to unoccupied mode. Command all occupied control dampers for this AHU to 20%. Wait 5 minutes.	Static pressure should stabilize at 0.15"		
b. Command one control damper to 100%. When static pressure reaches 0.4", command damper to 90%. Wait 5 minutes.	Static pressure should rise to 0.4" and stabilize.		
c. Command same damper to 100%. When static pressure reaches 0.6", command damper to 90%. Wait 5 minutes	Static pressure should rise to 0.6" and stabilize.		
d. Command same damper to 85%. When static pressure reaches 0.2", command damper to 90%.	Static pressure should fall to 0.2" and stabilize.		
(adjust static pressure points equally so maximum is at P-max determined by air balancer)	*Observe that controls are stable with no hunting or oscillation*		

AHU#:___________________	Expected response	Observed response	Pass?
5. Static pressure reset *(single isolation zone)* a. Command all isolation zones on the 3rd floors to unoccupied mode. (there should be one 6th floor isolation zone occupied) command occupied control damper for this AHU to 20%. Wait until system is stabile 5 minutes. b. Command control damper to 100%. When static pressure reaches 0.4", command damper to 90%. Wait 5 minutes. c. Command damper to 100%. When static pressure reaches 0.6", command damper to 90%. Wait 5 minutes d. Command damper to 85%. When static pressure reaches 0.2", command damper to 90%. e. Return all damper controls to auto. *(adjust static pressure points equally so maximum is at P-max determined by air balancer)*	Static pressure should stabilize at 0.15" Static pressure should rise to 0.4" and stabilize. Static pressure should rise to 0.6" and stabilize. Static pressure should fall to 0.2" and stabilize. *Observe that controls are stable with no hunting or oscillation*		
6. Fan Discharge Hi Static Alarm a. Start with the fans on (at least one zone in occupied mode). b. Pull out the fan discharge pressure sensor tube from the duct side of the high-limit DP switch and insert into a manual device for pressurizing it. c. Pressurize the sensor to a reading of 3.2". wait 5 minutes. d. return all systems to normal.	Alarm should occur when pressure exceeds 3.0" (adj.) The fans should be locked out until they are reset by the reset DO point or a push-button on the panel face. A pilot light on the panel face should indicate high pressure lockout is in effect.		

AHU#:__________________	Expected response	Observed response	Pass?
7. Mixed Air Plenum Low Static Alarm a. Start with the fans on (at least one zone in occupied mode). Differential pressure in the mixed air plenum should be greater than –1.0" b. Insert the tube from the side of the DP sensor that is outside the mixed air plenum into a manual device for pressurizing it. c. Pressurize the sensor until Mixed Air Plenum DP sensor reads –1.5" Wait 5 minutes. d. Return all systems to normal.	Alarm should occur when pressure falls below -1.0" (adj.) The fans should be locked out until they are reset by the reset DO point or a push-button on the panel face. A pilot light on the panel face should indicate low pressure lockout is in effect.		
8. High Duct Static Alarm a. Start with the fans on. b. Observe current VFD signal (e.g. 30 Hz). c. Override automatic control and command VFD signal to observed setting above. d. Insert the tube from the duct side of the duct DP sensor into a manual device for pressurizing it. e. Pressurize the sensor to a reading of P-Max + 1.0", where P-Max is determined by air balancer. Wait 5 minutes. f. Return all systems to normal.	Level 2 high static alarm.		

AHU#:__________________	Expected response	Observed response	Pass?
9. Low Duct Static Alarm a. Start with the fans on. b. Observe current VFD signal (e.g. 30 Hz). c. Override automatic control and command VFD signal to observed setting above. d. Pull out the tube from the duct side of the duct DP sensor. Sensor should now read 0.0". Wait 5 minutes. e. Return all systems to normal.	Level 2 low static alarm.		
10. Supply fan staging a. Observe supply fan lead/lag during previous testing. b. If responses were not observed, then: 1) Set minimum static pressure 0.2”. Let fans ramp down and observe for lag fan shutdown. 2) Set maximum static pressure *(as determined by air balancer)* and observe for fan ramp up and lag fan start. 3) Return controls to auto.	Lead fan shall start first. When lead fan is above 90% speed for 5 minutes, the lag fan shall start. Both fans should be controlled to the same speed when both are on. When fan speed is at the minimum speed for 15 minutes, the lag fan is shut off.		
11. Underfloor damper control a. Command all isolation zones to occupied mode. Command all thermostat settings to default values.	Static pressure should stabilize. Control damper positions should stabilize. If static pressure setpoint > 0.15” then at least one damper should be at 90% open.		

AHU#:__________________	Expected response	Observed response	Pass?
b. Release all control dampers to auto. c. Wait until all floor zones are satisfied.	Static pressure should stabilize. Control damper positions should stabilize. If static pressure setpoint > 0.15” then at least one damper should be at 90% open.		
d. Command 2^{nd} floor zone average temperature setpoint to 10°F below current zone temps. e. Wait until system has stabilized	Underfloor static setpoint should rise to a maximum of 0.2”. Underfloor static pressure should track with setpoint. Control dampers should stabilize at 90%.		
f. Command 2^{nd} floor zone average temperature setpoint to 10°F above current zone temps. g. Wait until system has stabilized	Underfloor static setpoint should lower to a minimum of 0”. Underfloor static pressure should track with setpoint.		
h. Return zone setpoints to normal			

AHU#:__________________	**Expected response**	**Observed response**	**Pass?**
12. Supply air temp reset a. During all AHU testing	Setpoint is reset from 63°F when the outdoor air temperature is 60°F and above, proportionally up to 65°F when the outdoor air temperature is 55°F and below. During night purge mode, supply air temperature setpoint shall be equal to the outdoor air temperature		
13. Supply air temp control a. This test should be performed when 60°F < OAT < 75°F, if at all possible (i.e. the test may need to be performed at night.) Chilled water system must be available and in auto. b. Command all isolation zones to occupied mode	AHU should follow sequence (refer to spec): 		
c. Lower average zone temperature setpoint to 10°F below current average zone temperature. d. Command supply air setpoint 3°F higher than outdoor air temperature.	Zone control dampers open, load applied to system PID loop output goes to 0 Economizer dampers shut, return dampers open, CHW pump off. *System to follow previous sequence* (see diagram)		

AHU#:____________________	**Expected response**	**Observed response**	**Pass?**
e. Decrease supply air setpoint in 2°F increments allowing system to stabilize between changes f. Continue until CHW pump is at 100%	Economizer dampers should open, following with return dampers closing. CHW pump to start at when it's speed signal is 20% for 5 minutes. (see diagram) *Observe that controls are stable with no hunting or oscillation*.		
g. Increase supply air setpoint in 2°F increments allowing system to stabilize between changes h. Continue until CHW pump is at off	CHW pump to stop when it's speed signal is 0% or less than 10% for 5 minutes. (see diagram) When CHW pump is off observe that coil bypass damper is fully open. *Observe that controls are stable with no hunting or oscillation*.		

AHU#:___________________	Expected response	Observed response	Pass?
14. Economizer a. With at least one zone in occupied mode. If OAT is < RAT then override OAT and set OAT = RAT + 3°F. If OAT is > RAT then override OAT and set OAT = RAT- 3°F.	Return air damper fully opened, economizer outdoor air dampers fully shut whenever the outdoor air temperature is greater than return air temperature. When system locks out economizer dampers, minimum outside air fan will start.		
15. Pre-cooling system: Case 1 Hot Weather Economizer Lockout OAT > RAT + 3°F a. Ensure AHU is running in normal occupancy b. If not, set CW supply setpoint to OAT –3°F c. Ensure that system is in economizer lockout d. Raise CW supply setpoint to OAT + 2°F	Outdoor air fan will start Condenser coil valve will open. Condenser coil valve will close.		
e. Minimum outdoor air damper to maintain minimum outdoor air rate	If it is not observed, modify minimum outdoor air setpoint to ensure that system will track.	Min outside air rate setpoint:________ Min outside air rate:________	
16. Pre-cooling system: Case 2 Cold Weather a. Ensure AHU is running in normal occupancy b. Lockout cooling coil pumps. c. Command economizer dampers closed until rate through economizer dampers is less than minimum outside air rate.	Economizer damper flow rate: $CFM_{OA} = CFM_{SA} \frac{RAT - SAT}{RAT - OAT}$ Outdoor air fan will start	Min outside air rate setpoint:________ CFM_{sa}:________	
d. Minimum outdoor air damper to maintain minimum outdoor air rate e. Minimum outside damper rate setpoint to equal minimum rate + 10% - economizer flow rate	Minimum outside damper opens. Minimum outside rate is maintained.	Min outside damper rate setpoint:________ CFM_{sa}:________ Econ flow rate:________ Min outside flow rate:________	

AHU#:__________________	Expected response	Observed response	Pass?
f. Modify economizer damper position to reduce economizer flow rate	Minimum outside damper opens. Minimum outside rate is maintained.	Min outside damper rate setpoint:________ CFM_{sa}:________ Econ flow rate:________ Min outside flow rate:________	
g. Raise CWST to OAT +3°F h. Lower CWST to OAT – 1°F	Condenser coil valve will open. Condenser coil valve will close.		
17. Pre-cooling system: Case 3 Moderate Weather a. Ensure AHU is running in normal occupancy b. Primary CW pump in on c. Set supply air temperature setpoint (SAS) so that SAS + 1°F < OAT d. Lower open circuit CWST temperature to < OAT – 7°F	Outdoor air fan will start minimum outside air damper will open fully condenser coil valve will open		
e. Shutoff all primary CW pumps. f. Restart pumps	Outdoor air fan will stops minimum outside air damper will closes condenser coil valve will closes. Outdoor air fan will start minimum outside air damper will open fully condenser coil valve will open.		
g. Raise SAS > OAT h. Restore SAS to previous value	Outdoor air fan will stops minimum outside air damper will closes condenser coil valve will closes. Outdoor air fan will start minimum outside air damper will open fully condenser coil valve will open.		

AHU#:___________________	Expected response	Observed response	Pass?
i. Raise open circuit CWST > OAT – 4°F (field determine this 4°F value as that which results in a supply air temperature off the pre-cool coil that is less than the supply air temperature by a degree or so, enough to make the cooling effect offset the added outdoor air fan and pump energy.)	Outdoor air fan will stops minimum outside air damper will closes condenser coil valve will closes.		
j. Restore systems to normal			
18. Coil bypass damper *this test should be performed when 63°F < OAT, RH < 75%. Chilled water system must be available and in auto.* a. *(if not observed above)* command coil CH pump off	When pump is off, bypass damper is fully open (min-p = 100%)		
b. Command SAS to 63°F, supply air dew point temperature to 57°F	CH pump should start, ramp to maintain SAT = 60°F, (min-p = 0%) coil bypass damper and OA damper should modulate in series to maintain supply air dew point = 57°F. If RH < 80%, PID should be = 0%. PID loop map 0-50%, bypass damper 0-100%, loop 50-100%, OA max-p 100-0%		
c. Calculate supply air dew point by standard methods using supply air temperature and supply air relative humidity	Calculated dew point should equal system generated dew point.		

AHU#:___________________	**Expected response**	**Observed response**	**Pass?**
d. Command supply air RH to 90%	Dew point should equal 60°F (at 63°F SAT) Bypass damper will ramp to fully open, then outdoor air economizer damper will ramp to full closed. (as per above sequence) supply air temperature should be maintained at setpoint. *Observe that controls are stable with no hunting or oscillation.*		
e. Restore supply air RH to normal	Outdoor air dampers ramp close and then bypass dampers. *Observe that controls are stable with no hunting or oscillation.*		

AHU#:__________________	Expected response	Observed response	Pass?
19. Supply fan system efficiency a. During all AHU testing	Predicted supply fan efficiency should be within about 20% of actual efficiency. $KW_{part-load} = KW_D\left(0.1461 - 0.82PLR + 1.6569PLR^2\right)$ KW_D = fan power at peak airflow rate PLR = measured airflow / by the peak airflow. *(peak airflow and associate kW shall be determined during commissioning by setting all terminal boxes to operate at design maximum airflow rate.)*	Measured kW:________ PLR:________ KW_D:________ Calculated kW:________	
20. Filter pressure drop alarm. a. With AHU in normal operation, command VFD signal to 30% speed. Observe that filter DP is less than 18% of DP_{100}. b. Using sheets of cardboard (or plywood, etc.) begin to block off sections of the filter. Keep adding sheets until filter DP exceeds 25% of DP_{100}. Wait 5 minutes. c. Restore all systems to normal.	Level 5 alarm when filter pressure drop reaches 18% of DP_{100}	Be sure to indicate the value of DP_{100}	
21. HOA Override Alarm (Manual ON) a. With AHU in unoccupied mode and all fans off. b. Turn on a fan using the HOA switch. Wait 70 seconds. c. Return all systems to normal.	Level 4 alarm as follows: "FAN ALARM. [Fan mark] fan is on when it should be off. Check HOA switch at starter or VFD."		

AHU#:__________________	Expected response	Observed response	Pass?
22. HOA Override Alarm (Manual OFF) a. With AHU in occupied mode and all fans on. b. Turn off a fan using the HOA switch. Wait 70 seconds. c. Return all systems to normal.	FMCS shall switch the fan to "lag" (if there are redundant fans in parallel), show the fan in alarm on graphic displays, and enunciate a level 2 alarm as follows: "FAN FAILURE ALARM. [Fan mark] fan failed to prove operation. Check belt, motor, power, status point, etc. and reset immediately."		
23. Freeze Alarm. a. With system in normal operation. b. Remove supply duct temperature sensor from duct and immerse in an ice bath. c. Wait until sensor reading drops below 35°F for at least 4 minutes. d. Return all systems to normal.	Level 2 alarm. Upon freeze alarm, FMCS shall override normal programming and shut the fan off and close outdoor air dampers.		
24. Cooling Coil dT Alarm. a. With system in normal operation and all chillers off. b. Observe that secondary CHP serving this AHU is off. c. Temporarily override the cooling coil dT alarm time delay from 30 minutes to 2 minutes. d. Use a hairdryer to increase the reading of the upstream temperature sensor e. Temperature drop across cooling coil should exceed 2°F for at least 2 minutes.	FMCS shall enunciate the following alarm at level 3 priority: "ENERGY WASTE: An unexpected temperature drop is occurring across the cooling coil. Please check for leaking valve or faulty controls."		

AHU#:__________________	Expected response	Observed response	Pass?
25. Underfloor plenum water detection. a. With all systems in normal operation. b. Pour some water near one of the underfloor plenum water detectors. c. Remove all the water.	Level 1 alarm. The alarm should indicate exactly where in the building the water was detected. FMCS should indicate when water is no longer present.		

VII. BUILDING PRESSURIZATION RELIEF FAN CONTROL

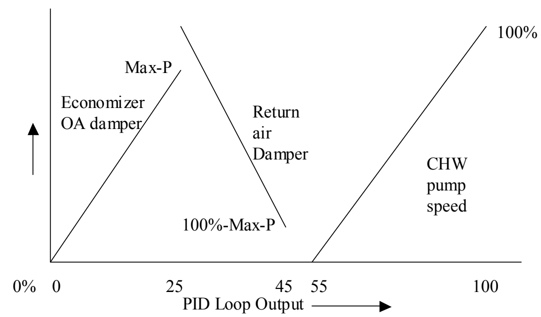
A. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Building static pressure north and south, building static pressure setpoint, relief fan PID and % speed reset.
2. Applicable economizer damper positions, return damper positions, control PIDs
3. All relief fan start/stop and status.

B. Functional tests:

Test	Expected response	Observed response	Pass?
1. Relief fans (one isolation zone, one AHU) a. Shutdown all AHU and AC units, all isolation zones closed.	All supply and relief fans off.		
b. Start one isolation zone on the 3rd floor. *Chose isolation zone to be the farthest away from the north and south building pressure sensors located on the 2nd floor.*	AHU ?? Lead fan start. *To be determined by isolation zone*		
c. Manually set AHU Supply air temperature control (SAT) PID to 0%. System should be on min outdoor air control with economizer at 0%. Wait until building pressure has maintained a stable state for 3 minutes.	Economizer dampers should be fully closed.		

<table>
<tr><th>Test</th><th>Expected response</th><th>Observed response</th><th>Pass?</th></tr>
<tr><td>d. Raise SAT PID in 10% increments.
e. Repeat up to 50%.

allow system to stabilize prior to next increment.</td><td>Economizer dampers should open, then return air dampers close according to the following map.

Relief fans for operating system should stage on as necessary to maintain building pressure.
Building pressure should be maintained at 0.08” with no hunting or oscillation in fan controls</td><td></td><td></td></tr>
<tr><td>2. Relief fans (two floors, all AHU)
a. Enable all 3rd and 6th floor isolation zones.</td><td>All AHU systems start.</td><td></td><td></td></tr>
<tr><td>b. Manually set all AHU SAT PID loops to 0%. Wait until building pressure has maintained a stable state for 3 minutes.</td><td>Systems should be on min outdoor air control with economizers dampers at 0%.</td><td></td><td></td></tr>
<tr><td>c. Raise SAT PID in 10% increments.
d. Repeat up to 50% SAT PID.

allow system to stabilize prior to next increment..</td><td>Economizer dampers should open, then return air dampers close (see previous diagram.)
Relief fans for AHU systems should stage on as necessary to maintain building pressure.
Building pressure should be maintained at 0.08” with no hunting or oscillation in fan controls</td><td></td><td></td></tr>
</table>

Test	Expected response	Observed response	Pass?
3. Relief fans (all floors, all AHU and AC) a. Enable all isolation zones.	All systems running.		
b. Manually set all AHU SAT PID loops to 0%. Wait until building pressure has maintained a stable state for 3min.	Systems should be on min outdoor air control with economizers dampers at 0%.		
c. Raise SAT PID in 10% increments. d. Repeat up to 50% SAT PID. *allow system to stabilize prior to next increment..*	Economizer dampers should open, then return air dampers close (see previous diagram.) Relief fans for AHU systems should stage on as necessary to maintain building pressure. Building pressure should be maintained at 0.08” with no hunting or oscillation in fan controls		

VIII. UNDERFLOOR FAN BOXES

A. Sampling strategy

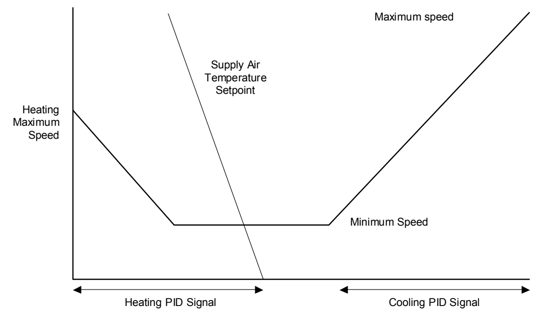
Test at least 10 boxes of this type. Select boxes on different AHUs, different floors, different proximity to hot water riser, etc. For every box that fails, fix the problems and retest that box plus one additional box.

B. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Fan speed signal, HW valve signal, supply temp of associated AHU.
2. Supply air temp, room air temp, thermostat setpoint (including setpoint adjust)
3. Heating loop output, cooling loop output, zone mode.

C. Functional tests:. Copy this table for each box tested.

VAV box #: ___________	Expected response	Observed response	Pass?
1. Command underfloor static pressure setpoint to design pressure and isolation zone to occupied mode.		Include description of space loads (i.e. Outdoor air temp and solar gain and people, lights and equipment in space). Include detailed logs of design and measured CFM per outlet.	
2. Deadband mode a. If zone is not currently in deadband mode (min fan speed and heating valve shut) then, set cooling setpoint to 2°F above current space temp and heating setpoint to 2°F below current space temp.	Mode: Deadband minimum fan speed, heating valve shut, SAS = 65°F, heating PID =0%, cooling PID=0% Minimum speed shall be 10% or lowest speed allowed by motor/control manufacturer, which ever is higher.	Minimum speed:_______	
3. Cooling mode a. Set heating setpoint to 6°F below space temperature, set cooling setpoint to 4°F below space temp, 1) When fan is at max speed, *(as determined by air balancer)* measure CFM from all diffusers on that zone with a flow hood.	Mode: Cooling Fan speed should slowly increase to max speed, then slowly decrease as room temperature reaches setpoint. At max speed, all CFMs should equal design cooling CFMs.	Design press:_______ actual:___________ Design CFM:_______ actual:___________ Max cooling fan speed: _________	

VAV box #: ___________	**Expected response**	**Observed response**	**Pass?**
4. Heating mode *(exclude if VAV has no heating coil)* a. Set cooling setpoint to 6°F above space temperature, set heating setpoint to 4°F above space temp, 1) Monitor system 2) Restore default setpoints when completed	Typical initial mode: Cooling fan speed should slowly decrease to minimum speed, Mode: Deadband, then Mode: Heating Heating PID should increase from 0% → 100%, SAT setpoint reset from 65°F → 130°F, then fan speed increase min speed → 30% cooling fan speed max. 	Supply air setpoint: Min: ________ Max: ________ Fan speed: Min: ________ Max heating: ________	
5. Setpoints a. Isolation zone mode: occupied	In Occupied mode, (default setpoints) Occupied heating = 70°F Occupied cooling= 73°F (interior)/ 74°F (exterior)	Actual setpoints Occupied heating: _______ Occupied cooling: _______	
b. Attempt: 1) To set unoccupied heating setpoint 1°F above occupied heating setpoint. 2) To set unoccupied cooling setpoint 1°F below occupied cooling setpoint. 3) To set occupied cooling setpoint 1°F below occupied heating setpoint.	None of the conditions are to be allowed.		

VAV box #: ___________	Expected response	Observed response	Pass?
c. Set both heating and cooling setpoints to 2°F below space temp (heating setpoint = cooling setpoint) d. Wait until system has stabilized e. Restore default setpoints	Heating loop and cooling loop cannot both be greater than 0 at the same time. Heating and Cooling mode may not coincide No hunting (repeated switching from heating to cooling mode).		
f. Set isolation zone to unoccupied mode,	In Unoccupied mode, (default setpoints) Unoccupied heating = 60°F Unoccupied cooling = 90°F	Actual setpoints Unoccupied heating: _______ Unoccupied cooling: _______	
g. Restore box to normal			
6. High zone temperature alarm (occupied mode). a. With zone in occupied mode. b. Disable fan box (e.g. disconnect power) c. Use a hair dryer to raise the temperature at the zone thermostat above 78°F. d. Restore box to normal. THIS TEST SHOULD BE PERFORMED FOR AT LEAST ONE SPECIAL ROOM SUCH AS A SERVER ROOM.	Level 4 alarm. Should indicate exact location of alarm. Level 3 alarm for special rooms such as server rooms.		
7. High zone temperature alarm (unoccupied mode). a. With zone in unoccupied mode. b. Disable fan box (e.g. disconnect power) c. Use a hair dryer to raise the temperature at the zone thermostat 5°F above cooling setup setpoint. d. Restore box to normal.	Level 5 alarm. Should indicate exact location of alarm.		

IX. FIRST FLOOR PARALLEL FAN BOXES

A. Sampling strategy

Test at least 5 boxes of this type. Select boxes on different AHU, perimeter and interior, different proximity to hot w riser, etc. For every box that fails, fix the problems and retest that box plus one additional box.

B. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Fan status, HW valve signal, supply air temp, room temp, thermostat setpoints (including setpoint adjust), supply temp of associated AC.
2. Heating loop output, cooling loop output, supply air volume, supply damper position, isolation zone mode

C. Functional tests:

Box #:_________________	Expected response	Observed response	Pass?
1. 1st floor AHU in occupied mode If not already equal to, set supply air setpoint at 53°F. Duct static setpoint set to design pressure	AHU on Supply air temperature equal to 53°F Design pressure: __________	SAT: __________ Static Press: _________ Include description of space loads (i.e. Outdoor air temp and solar gain and people, lights and equipment in space). Include detailed logs of design and measured CFM per outlet.	
2. Deadband mode: a. If zone is not currently in deadband mode then set cooling setpoint to 2°F above current space temp and heating setpoint to 2°F below current space temp. 1) Heating CFM. Measure CFM from all diffusers on that zone with a flow hood.	Heating valve is shut. Parallel fan on. SAT setpoint = 55°F Diffuser CFM = Heating CFM, within about 10% Total design CFM: _______	Supply CFM @DDC: _______ Actual: ________	
2) Min CFM. Command parallel fan off. Measure CFM from all diffusers on that zone with a flow hood. Release fan to auto.	Perimeter zones min volume = 0. Interior zone min volume CFM should equal Design Min CFM, within about 10%. Total design CFM: _______	Supply CFM @DDC: _______ Actual: ________	

Box #:_________________	Expected response	Observed response	Pass?
3. Cooling Mode a. Set heating setpoint to 6°F below space temperature, set cooling setpoint to 4°F below space temp, 1) When fan is at max CFM, measure CFM from all diffusers on that zone with a flow hood.	Mode: Cooling Parallel fan off, heating valve shut, heating supply air setpoint = 55°F CFM should slowly increase to maximum max CFM actual should equal design max CFM, within 10%. Total design CFM: _______	Supply CFM @DDC: _______ Actual: ________	
4. Heating Mode a. Set cooling setpoint to 6°F above space temperature, set heating setpoint to 4°F above space.	Mode: Heating CFM should slowly decrease to min CFM (if not already at min CFM.) Parallel fan comes on. Heating PID should increase from 0% → 100%, SAT setpoint reset from 55°F → 100°F Supply air temperature should track with setpoint		
b. Command supply air setpoint to 80°F c. Restore box to normal.	Supply air temperature should track and maintain 80°F . *Observe that controls are stable with no hunting or oscillation.*		

Box #:_________________	Expected response	Observed response	Pass?
5. Setpoints a. Isolation zone mode: Occupied	In Occupied mode, (default setpoints) Occupied heating = 70°F Occupied cooling= 73°F (interior)/ 74°F (exterior)	Actual setpoints Occupied heating: _______ Occupied cooling: _______	
b. Attempt: 1) To set unoccupied heating setpoint 1°F above occupied heating setpoint. 2) To set unoccupied cooling setpoint 1°F below occupied cooling setpoint. 3) To set occupied cooling setpoint 1°F below occupied heating setpoint.	None of the conditions are to be allowed.		
c. Set both heating and cooling setpoints to 2°F below space temp (heating setpoint = cooling setpoint) d. Wait until system has stabilized e. Restore default setpoints	Heating loop and cooling loop cannot both be greater than 0 at the same time. Heating and cooling mode may not coincide No hunting (repeated switching from heating to cooling mode).		
f. Set isolation zone to Unoccupied mode,	In Unoccupied mode, (default setpoints) Unoccupied heating = 60°F Unoccupied cooling= 90°F	Actual setpoints Unoccupied heating: _______ Unoccupied cooling: _______	
g. Restore box to normal			

Box #:_________________	Expected response	Observed response	Pass?
6. High zone temperature alarm (occupied mode). a. With zone in occupied mode. b. Disable VAV box (e.g. disconnect power) c. Use a hair dryer to raise the temperature at the zone thermostat above 78°F. d. Restore box to normal.	Level 4 alarm. Should indicate exact location of alarm.		

X.FIRST FLOOR VAV AHU

A. Sampling strategy

AC-3 and AC-4 are effectively a single AHU since they serve a common plenum. Therefore they are tested together.

B. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Isolation zone mode for all isolation zones on that AHU, AHU system mode.
2. Static pressure setpoint, static pressure, position of all VAV box dampers (use a single color/line type for all dampers in each isolation zone)
3. AC-3 & 4 speed, static pressure setpoint, static pressure.
4. All floor 1 space temperatures and heating and cooling setpoints. (separate colors/line types for interior vs. Perimeter zones)
5. SAT, OAT, RAT, MAT,
6. Pre-cool OA temperature, min OA setpoint, PCC valve position, OA fan status
7. Economizer lockout, economizer OA damper position, return air damper position, max-p
8. Building pressure, relief fan A, B, C, D, E, F% speed
9. Supply air flow rate north and south, min OA damper flow rate
10. Actual system supply fan efficiency (kW/1000 CFM), predicted system supply fan efficiency.

C. Functional tests:.

Test	Expected response	Observed response	Pass?
1. System mode a. Command all isolation zones to Unoccupied mode. b. Command 2 isolation zones to Setback mode. c. Command 1 isolation zone to Warm-up mode. d. Command 1 zone to Setup mode. e. Command 1 zone to Cool-down mode. f. Command 1 zone to Setback.	System mode: Unoccupied System mode: Setback System mode: Warm-up System mode: Setup System mode: Cool-down System mode: Setup		
2. Minimum outside air setpoint a. Command 1 zone to occupied mode. b. Command 2 zones to occupied. c. Command all zones to occupied.	System mode: Occupied Minimum outdoor air setpoint should increase by the ratio of active (occupied) isolation zones to overall floor area served by the system. Min OA fan and PCC coil should run if economizer locked out or very cold or CWST < OAT + 5°F (refer to controls spec)		

Test	Expected response	Observed response	Pass?
3. Static pressure reset *(all zones)*			
a. Command all isolation zones to occupied mode. Command all occupied control dampers for this AHU to 20%. Wait 5 minutes.	Static pressure setpoint should equal 0.5" Static pressure should stabilize at 0.5"		
b. Command one control damper to 100%. When static pressure setpoint reaches 1.25", command damper to 90%. Wait 5 minutes.	Static pressure setpoint should equal 1.25" Static pressure should rise to 1.25" and stabilize.		
c. Command same damper to 100%. When static pressure setpoint reaches maximum, command damper to 90%. Wait 5 minutes	Static pressure setpoint should equal 1.75" Static pressure should rise to 1.75" and stabilize.		
d. Command same damper to 85%. When static pressure setpoint reaches 0.75", command damper to 90%.	Static pressure setpoint should equal 0.75" Static pressure should fall to 0.75" and stabilize.		
(adjust static pressure points equally so that maximum and minimum are as determined by air balancer)	*Observe that controls are stable with no hunting or oscillation*		

Test	Expected response	Observed response	Pass?
4. Static pressure reset (single isolation zone)			
a. Command all 2 isolation zones to unoccupied mode. (there should be only one isolation zone occupied) command all occupied control dampers for this AHU to 20%. Wait 5 minutes.	Static pressure setpoint should equal 0.5" Static pressure should stabilize at 0.5"		
b. Command one control damper to 100%. When static pressure setpoint reaches 1.25", command damper to 90%. Wait 5 minutes.	Static pressure setpoint should equal 1.25" Static pressure should rise to 1.25" and stabilize.		
c. Command same damper to 100%. When static pressure setpoint reaches maximum, command damper to 90%. Wait 5 minutes	Static pressure setpoint should equal 1.75" Static pressure should rise to 1.75" and stabilize.		
d. Command same damper to 50%. When static pressure setpoint reaches 0.75", command damper to 90%. Wait 5 minutes	Static pressure setpoint should equal 0.75" Static pressure should fall to 0.75" and stabilize.		
(adjust static pressure points equally so that minimum and maximum are those determined by air balancer)	*Observe that controls are stable with no hunting or oscillation*		

Test	Expected response	Observed response	Pass?
5. AHU supply fan AC-3 and AC-4 a. Observe AHU tracking during previous testing.	AC-3 and AC-4 are effectively a single air handler since they serve a common plenum. Both fans always run together (not lead-lag alternated due to asymmetry). The two static pressure sensor pickups (provided with each unit from Trane) shall be extended to near the end of the north duct main and the south duct main. They shall be piped together so that signals are averaged. Each AC unit fan speed shall be controlled independently by internal Trane controls to maintain duct static at setpoint. The setpoint for the north AC unit shall be the setpoint reset by zone demand. The setpoint for the south unit shall be the same if the north unit fan is proven off. In order to keep the fans from hunting when both units are proven on, the static pressure setpoint of south unit shall be reset by a control loop on south unit fan speed with a setpoint equal to the fan speed of the north unit, time averaged over 3 minutes.		
b. Set static pressure setpoint to 1.25”	System static pressure should stabilize at 1.25” AC-3 static pressure output should equal 1.25” AC-4 speed should equal AC-3	System static pressure setpoint: ________ System static pressure: ________ AC-3 static pressure: _______ AC-3 speed: _______ AC-4 static pressure setpoint: ________ AC-4 speed: ________	

Test	Expected response	Observed response	Pass?
c. Set static pressure setpoint to 1.5”	System static pressure should stabilize at 1.5” AC-3 static pressure output should equal 1.5” AC-4 speed should equal AC-3	System static pressure setpoint: ________ System static pressure: ________ AC-3 static pressure: _______ AC-3 speed: _______ AC-4 static pressure setpoint: ________ AC-4 speed: ________	

Test	Expected response	Observed response	Pass?
6. High Duct Static Alarm a. Start with the fans on. b. Observe current VFD signal (e.g. 30 Hz). c. Override automatic control and command VFD signal to observed setting above. d. Insert the tube from the duct side of the duct DP sensor into a manual device for pressurizing it. e. Pressurize the sensor to a reading of 3.0". Wait 5 minutes. f. Return all systems to normal.	Level 2 high static alarm.		
7. Low Duct Static Alarm a. Start with the fans on. b. Observe current VFD signal (e.g. 30 Hz). c. Override automatic control and command VFD signal to observed setting above. d. Pull out the tube from the duct side of the duct DP sensor. Sensor should now read 0.0". Wait 5 minutes. e. Return all systems to normal.	Level 2 low static alarm.		
8. Single south AHU AC-4 on a. Shutdown AC-3 b. Close north isolation zones to reduce overall system demand. c. Set static pressure setpoint to 0.75” d. At completion, restore all systems to normal.	System / AC-4 static pressure should stabilize at 0.75”	System static pressure setpoint: ________ AC-4 static pressure setpoint: ________ AC-4 speed: ________	

Test	Expected response	Observed response	Pass?
9. Supply air temp reset a. During all AHU testing	Setpoint is reset from T-min (53°F) when the outdoor air temperature is 60°F and above, proportionally up to T-max when the outdoor air temperature is 55°F and below. T-max shall range from 55°F to 63°F and shall be the output of a slow-acting PID loop that maintains the zone furthest from setpoint at setpoint plus 1°F. During setup or cool-down modes, T-max shall be set to T-min		
10. Supply air temperature setpoint (T–max) a. Set max zone error to 5°F above setpoint b. Set max zone error to 5°F below setpoint c. Set system mode to setup d. Set system mode to cool-down e. Set system mode to occupied	T-max should slowly reset down to 55°F T-max should slowly reset up to 63°F T-max should equal T-min T-max should equal T-min T-max should reset to auto	T-max:______ T-max:______ T-max:______ T-min:______ T-max:______ T-min:______	
11. Supply air temperature setpoint (SAS) and supply air temperature (SAT) *(allow sufficient time for system to respond between steps)* *to be completed when return air temperatures are greater than 70°F* a. Manually set outside air temperature to 65°F b. Manually set outside air temperature to 60°F c. Manually set outside air temperature to 57.5°F d. Manually set outside air temperature to 55°F	Supply air setpoint equal to 53°F Supply air setpoint equal to 53°F Supply air setpoint = calculated SAS:_______ [(T-max – T-min) / 2 + T-min] Supply air setpoint equal to T-min *(supply air temperature should track setpoint)*	T-max:______ T-min:______ SAS:_______ SAS:_______ SAT:_______ SAS:_______ SAT:_______ SAS:_______ SAT:_______ SAS:_______ SAT:_______	

Test	Expected response	Observed response	Pass?
12. Supply air temp control (II) if previous test is successful without compressor coming on then a. Command all isolation zones (IZ) to unoccupied. Command one IZ to occupied. Bring all space temps up in IZ up to at least 73°F b. Set heating to 70°F and cooling to 74°F so that all spaces are in deadband c. Command economizer damper to shut d. Set all cooling setpoints in that IZ to 69°F. Wait for spaces to be satisfied.			
13. Relief fans a. Command economizer damper full open and return air damper shut. Command control dampers to full open b. Slowly increase SF-A, B speed from 0 to 100% over at least 1 hour. c. Slowly decrease SF-A, B speed from 100% to 0% over at least 1 hour.	Building pressure should be maintained at 0.08". Relief fans should stage on as necessary.		
14. Economizer and PCC a. With at least one zone in occupied mode. If OAT is < RAT then override OAT and set OAT = RAT + 3°F. If OAT is > RAT then override OAT and set OAT = RAT- 3°F.	Return air damper fully opened, economizer outdoor air dampers fully shut whenever the outdoor air temperature is greater than return air temperature. When system locks out economizer dampers, minimum outside air fan will start.		

Test	Expected response	Observed response	Pass?
15. Pre-cooling system: Case 1 Hot weather economizer lockout OAT > RAT + 3°F a. Ensure AHUs are running in normal occupancy b. If not, set CW supply temperature to OAT – 3°F c. Ensure that system is in economizer lockout d. Raise CW supply temperature to OAT + 2°F	Outdoor air fan will start. Condenser coil valve will modulate direct-acting, to maintain discharge equal to AC supply air setpoint. Condenser coil valve will modulate reverse-acting, to maintain discharge equal to AC supply air setpoint.		
e. Minimum outdoor air damper to maintain minimum outdoor air rate	If it is not observed, modify minimum outdoor air setpoint to ensure that system will track.	Min outside air rate setpoint:________ CFM_{sa}(north):________ CFM_{sa}(south):________ Min outside air rate:________	
16. Pre-cooling system: Case 2 cold weather a. Ensure AHU is running in normal occupancy b. Lockout cooling coil pumps. c. Command economizer dampers closed until rate through economizer dampers is less than minimum outside air rate.	Economizer flow rate: $CFM_{OA} = CFM_{SA}\frac{RAT-SAT}{RAT-OAT}$ Outdoor air fan will start	Min outside air rate setpoint:________	
d. Minimum outdoor air damper to maintain minimum outdoor air rate e. Minimum outside damper rate setpoint to equal minimum rate + 10% - economizer flow rate	Minimum outside damper opens. Minimum outside rate is maintained.	Min outside damper rate setpoint:________ CFM_{sa}(north):________ CFM_{sa}(south):________ Econ flow rate:________ Min outside flow rate:________	
f. Modify economizer damper position to reduce economizer flow rate	Minimum outside damper opens. Minimum outside rate is maintained.	Min outside damper rate setpoint:________ Econ flow rate:________ Min outside flow rate:________	

Test	Expected response	Observed response	Pass?
g. Lower CW supply temperature to OAT - 1°F h. Raise CW supply temperature to OAT + 3°F	Condenser coil valve will modulate direct-acting, to maintain discharge equal to AC supply air setpoint Condenser coil valve will modulate reverse-acting, to maintain discharge equal to AC supply air setpoint		
17. Pre-cooling system: Case 3 moderate weather a. Ensure AHU is running in normal occupancy b. Primary CW pump in on c. Set supply air temperature setpoint (SAS) so that SAS+1°F < OAT d. Lower open circuit CWST temperature to < OAT –7°F	Outdoor air fan will start minimum outside air damper will open fully condenser coil valve will modulate direct-acting, to maintain discharge equal to AC supply air setpoint		
e. Shutoff all primary CW pumps. f. Restart pumps	Outdoor air fan will stop Minimum outside air damper will close Condenser coil valve will close Outdoor air fan will start Minimum outside air damper will open fully Condenser coil valve will modulate direct-acting, to maintain discharge equal to AC supply air setpoint		

Test	Expected response	Observed response	Pass?
g. Raise SAS > OAT h. Restore SAS to previous value	Outdoor air fan will stops Minimum outside air damper will closes Condenser coil valve will closes Outdoor air fan will start Minimum outside air damper will open fully Condenser coil valve will modulate direct-acting, to maintain discharge equal to AC supply air setpoint		
i. Raise open circuit CWST temperature to > OAT –4°F (field determine this 4°F value as that which results in a supply air temperature off the pre-cool coil that is less than the supply air temperature by a degree or so, enough to make the cooling effect offset the added outdoor air fan and pump energy.)	Outdoor air fan will stops minimum outside air damper will closes condenser coil valve will closes.		
j. Restore systems to normal			

Test	Expected response	Observed response	Pass?
18. Supply fan system efficiency a. During all AHU testing	Predicted supply fan efficiency should be within about 20% of actual efficiency. $KW_{part-load} = KW_D\left(0.1461 - 0.82PLR + 1.6569PLR^2\right)$ KW_D = fan power at peak airflow rate PLR = measured airflow / by the peak airflow. *(peak airflow and associate kW shall be determined during commissioning by setting all terminal boxes to operate at design maximum airflow rate.)*	Measured kW:________ PLR:________ KW_D:________ Calculated kW:________	
19. Filter pressure drop alarm. a. With AHU in normal operation, command VFD signal to 30% speed. Observe that filter DP is less than 18% of DP_{100}. b. Using sheets of cardboard (or plywood, etc.) begin to block off sections of the filter. Keep adding sheets until filter DP exceeds 25% of DP_{100}.. Wait 5 minutes. c. Restore all systems to normal.	Level 5 alarm when filter pressure drop reaches 18% of DP_{100}	Be sure to indicate the value of DP_{100}	
20. HOA Override Alarm (Manual ON) a. With AHU in unoccupied mode and all fans off. b. Turn on a fan using the HOA switch. Wait 70 seconds. c. Return all systems to normal.	Level 4 alarm as follows: "FAN ALARM. [Fan mark] fan is on when it should be off. Check HOA switch at starter or VFD."		

Test	Expected response	Observed response	Pass?
21. HOA Override Alarm (Manual OFF) a. With AHU in occupied mode and all fans on. b. Turn off a fan using the HOA switch. Wait 70 seconds. c. Return all systems to normal.	FMCS shall switch the fan to "lag" (if there are redundant fans in parallel), show the fan in alarm on graphic displays, and enunciate a level 2 alarm as follows: "FAN FAILURE ALARM. [Fan mark] fan failed to prove operation. Check belt, motor, power, status point, etc. and reset immediately."		
22. Freeze Alarm. a. With system in normal operation. b. Remove supply duct temperature sensor from duct and immerse in an ice bath. c. Wait until sensor reading drops below 35°F for at least 4 minutes. d. Return all systems to normal.	Level 2 alarm. Upon freeze alarm, FMCS shall override normal programming and shut the fan off and close outdoor air dampers.		

XI. GARAGE SUPPLY AND EXHAUST

A. Graphing. Time step shall be <= 1 minutes or "change of value".

1. All CO concentrations
2. All supply and exhaust fan % speed and status, PID loop outputs

B. Functional tests:

Test	Expected response	Observed response	Pass?
1. Garage supply and exhaust in normal operation 2. Modify CO control PID as necessary to allow for false co concentration to input.	All supply and exhaust fans should modulate equally to maintain co concentration at 35 ppm.		
3. If there is a manned control booth: a. Command booth PID to 15%, general to 5% b. Command booth PID to 0% , general to 10% c. Restore PID signals to normal	Controlling signal should be 15% Controlling signal should be 10%		
4. Set CO concentration to 20ppm > setpoint.	PID should begin to ramp up. At 20% garage fans should start. Fan speed should track with PID output.		
5. When PID reaches 100%, set CO concentration to 20ppm < setpoint.	PID should ramp down At 0% garage fans should stop.		

6. High CO Concentration Alarm. Consult manufacturer's test procedures. OR a. In normal operation. b. Put a cardboard box or similar enclosure around one of the CO sensors. c. Using a CO gas canister or similar device, discharge CO into the enclosure until alarm is registered or CO sensor reading exceeds 200 ppm.	Level 1 high CO concentration alarm.		
7. At conclusion of test restore any control modifications made to facilitate test.			

XII. TELEPHONE OVERRIDE SYSTEM

A. Graphing. Time step shall be <= 1 minutes or "change of value".

1. Isolation zone mode for all isolation zones on tested AHU, AHU system mode, Min OA setpoint.
2. Tenant identification

B. Functional tests:

Test	Expected response	Observed response	Pass?
1. Telephone override a. Modify occupancy time schedule so that all systems are currently unoccupied b. Temporarily set the minimum override time to 5 minutes. c. Using a telephone, call for a tenant override in one isolation zone.	Isolation zone mode goes to occupied. System mode goes to occupied. Thermostat setpoints in that zone go to occupied setpoints. Fans come on. Minimum OA setpoint corresponds to the floor area ratio for that zone. All other zones remain in unoccupied mode. All other control dampers remain closed. All other fan boxes remain off Design Min OA setpoint:___________	AHU: __________ Isolation Zone: __________ Min OA setpoint: ____________	
d. After 2 minutes call for tenant override in another isolation zone	Isolation zone mode goes to occupied. System mode goes to remains occupied. Thermostat setpoints in that zone go to occupied setpoints. Minimum OA setpoint corresponds to the floor area ratio for that zone. All other zones remain in unoccupied mode. All other control dampers remain closed. All other fan boxes remain off Design Min OA setpoint:___________	AHU: __________ Isolation Zone: __________ Min OA setpoint: ____________	

Test	Expected response	Observed response	Pass?
e. At 5 minutes tenant override for initial zone should time out.	1st isolation zone mode goes to unoccupied. System mode remains occupied. Thermostat setpoints in that zone go to unoccupied setpoints. Minimum OA setpoint corresponds to the floor area ratio for that zone. Design Min OA setpoint:___________	Min OA setpoint: ____________	
f. At 7 minutes tenant override for 2nd zone should time out.	2nd isolation zone mode goes to unoccupied. System mode goes to unoccupied. Fans shutdown. Thermostat setpoints in that zone go to unoccupied setpoints.		
g. Restore occupancy time schedules and minimum override time.	System restored.		

MOTOR PRE-FUNCTIONAL TEST DATA SHEET   MOTOR OR CONTROLLER TAG ________

SECTION 15051 APPENDIX – A MOTOR AND CONTROLLER PRE-FUNCTIONAL TEST DATA SHEET

MOTOR DATA				
	AS DESIGNED	**AS FOUND**	**ACTION REQUIRED**	**DONE**
MANUFACTURER				
MODEL NO.				
SERIAL NO.				
TYPE				
FRAME				
H.P./RPM				
VOLTS/PHASE				
NAMEPLATE EFFICIENCY				
VARIABLE SPEED DRIVE DATA (if applicable)				
	AS DESIGNED	**AS FOUND**	**ACTION REQUIRED**	**DONE**
MANUFACTURER				
MODEL NO.				
SERIAL NO.				
MANUAL BYPASS (Y/N)				
INSTALLATION				
VIBRATION ISOLATION ADJUSTED?				
SHIPPING BLOCKS REMOVED?				
SEISMIC RESTRAINTS IN PLACE?				
MOTOR INSTALLED AND MOUNTED PROPERLY AND ROTATE FREELY?				
ALIGNMENT VERIFIED AND DRIVES ADJUSTED?				
DRIVE GUARD IN PLACE?				
MOTOR LUBRICATED?				
ELECTRICAL CONNECTIONS COMPLETE & TIGHT?				
DISCONNECT SWITCH INSTALLED WITHIN SIGHT OF MOTOR?				
OVERLOAD HEATERS - MODEL & SIZE				

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________   Printed December 3, 2003

REFERENCE SPECIFICATIONS FOR ENERGY AND RESOURCE EFFICIENCY

PUMP PRE-FUNCTIONAL TEST DATA SHEET PUMP TAG ________

	AS DESIGNED	AS FOUND	ACTION REQUIRED	DONE
PUMP DATA				
MANUFACTURER				
MODEL NO.				
SERIAL NO.				
NAMEPLATE GPM/HEAD				
VIBRATION ISOL MANUF.				
VIBRATION ISOLATION TYPE/DEFLECTION				
INLET PRESSURE (PSIG)				
PRESSURE GAUGE(S) QTY/ MANUF./PSI RANGE				
MOTOR AND CONTROLLER DATA COMPLETE FORM: SECTION 15051 APPENDIX A, MOTOR AND CONTROLLER PRE-FUNCTIONAL TEST DATA SHEET				
INSTALLATION				
VIBRATION ISOLATION ADJUSTED?				
SHIPPING BLOCKS REMOVED?				
SEISMIC RESTRAINTS IN PLACE?				
PUMP & MOTOR INSTALLED AND MOUNTED PROPERLY AND ROTATE FREELY?				
STRAINERS IN PLACE & SCREEN CLEANED?				
ALIGNMENT VERIFIED BY MILLWRIGHT/MANUF.?				
COUPLING GUARD IN PLACE?				
PUMP AND MOTOR LUBRICATED?				
PRESSURE GAUGE(S) INSTALLED?				
PIPING COMPLETE AND TESTED?				
INLET/OUTLET CORRECTLY CONNECTED?				
PIPE SUPPORTED INDEPENDENTLY FROM PUMP?				
LOCAL VALVING SET FOR NORMAL OPERATION?				
ELECTRICAL CONNECTIONS COMPLETE & TIGHT?				
DISCONNECT SWITCH INSTALLED?				
OVERLOAD HEATERS - MODEL & SIZE				

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________

Printed December 3, 2003

HYDRONIC SYSTEM PRE-FUNCTIONAL TEST DATA SHEETHYDRONIC SYSTEM TAG ________

SECTION 15180 APPENDIX A, HYDRONIC SYSTEM PRE-FUNCTIONAL TEST DATA SHEET

HYDRONIC SYSTEM DATA				
	AS DESIGNED	**AS FOUND/TESTED**	**ACTION REQUIRED**	**DONE**
PIPING MATERIAL				
INSULATION MATERIAL				
INSULATION THICKNESS				
SAFETY RELIEF PRESSURE				
EXP. TANK MANUF/MODEL				
EXP. TANK PRECHARGE PSI				
PRESSURE TEST PSI				
PRESSURE TEST DURATION				
CLEANING DURATION				
POUNDS OF TSP USED				
WATER TREATMENT				
MANUFACTURER/MODEL				
SERIAL NO.				
CONTROLLER TYPE				
INHIBITOR TYPE/GALS				
INHIBITOR PUMP				
BIOCIDE 1 TYPE/GALS				
BIOCIDE 2 TYPE/GALS				
BIOCIDE PUMP				
AUTO DRAIN VALVE				
INSTALLATION				
SPRING HANGERS WHERE SPECIFIED?				
SEISMIC SUPPORTS INSTALLED PER SPEC'S				
DIELECTRIC UNIONS AT COPPER/STEEL CONN.?				
EXPOSED PIPE INSULATION PROTECTED?				
PIPE INSULATION JACKET PER SPECIFICATIONS?				
PRESSURE RELIEF VALVE(S) INSTALLED?				
BACKFLOW PREVENTER INSTALLED?				
EXPANSION TANK CONNECTED?				
SYSTEM FLUSHED AFTER CLEANING?				
INHIBITOR IN SYSTEM?				
WATER TREATMENT CONTROLLER TESTED BY SUPPLIER (OPEN SYSTEM ONLY)?				
WATER TREATMENT REPORT SUBMITTED?				
AIR VENTS/REMOVAL SYSTEM INSTALLED?				
AIR REMOVED FROM SYSTEM?				
PIPING IDENTIFICATION & ARROWS INSTALLED?				
VALVES TAGGED AS SPECIFIED?				

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________

Printed December 3, 2003

HYDRONIC SYSTEM PRE-FUNCTIONAL TEST DATA SHEETHYDRONIC SYSTEM TAG ________

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________

AHU PRE-FUNCTIONAL TEST DATA SHEET AIR HANDLING UNIT/COIL TAG ________

SECTION 15720 APPENDIX A, AIR HANDLING UNITS PRE-FUNCTIONAL TEST DATA SHEET

AIR HANDLING UNITS AND COILS DATA				
	AS DESIGNED	**AS FOUND**	**ACTION REQUIRED**	**DONE**
MANUFACTURER				
MODEL NO.				
SERIAL NO.				
NAMEPLATE AIRFLOW				
VIBRATION ISOL MANUF.				
VIBRATION ISOLATION TYPE/DEFLECTION				
COOLING COIL ROWS/FINS				
HEATING COIL ROWS/FINS				
MOTOR SHEAVE MANUFACTURER/MODEL				
FAN PULLEY MANUFACTURER/MODEL				
FILTERS: QTY / TYPE / SIZE				
MOTOR AND CONTROLLER DATA COMPLETE FORM: SECTION 15051 APPENDIX A, MOTOR AND CONTROLLER PRE-FUNCTIONAL TEST DATA SHEET				

INSTALLATION			
VIBRATION ISOLATION ADJUSTED?			
SHIPPING BLOCKS REMOVED?			
SEISMIC RESTRAINTS IN PLACE?			
AIR HANDLING UNIT FAN & MOTOR INSTALLED AND MOUNTED PROPERLY AND ROTATE FREELY?			
STRAINERS IN PLACE & SCREEN CLEANED?			
FAN MOTORS LUBRICATED?			
CONDENSATE DRAIN PIPING INSTALLED WITH TRAP?			
FILTERS INSTALLED WITH NO AIR GAPS?			
FILTER PRESSURE GAGE INSTALLED?			
DUCT COMPLETE AND SEALED?			
DUCT SUPPORTED INDEPENDENTLY FROM FAN?			
INLET/DSICHARGE DAMPERS INSTALLED CORRECTLY?			
PIPING COMPLETE AND TESTED?			
PIPE CONNECTED CORRECTLY AT COILS AND SUPPORTED INDEPENDENTLY FROM AIR HANDLING UNITS?			
LOCAL VALVING SET FOR NORMAL OPERATION?			
ELECTRICAL CONNECTIONS COMPLETE & TIGHT?			
DISCONNECT SWITCH INSTALLED?			

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________

Printed December 3, 2003

AHU PRE-FUNCTIONAL TEST DATA SHEET AIR HANDLING UNIT/COIL TAG ________

OVERLOAD HEATERS - MODEL & SIZE			

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________

Printed December 3, 2003

CRAC PRE-FUNCTIONAL TEST DATA SHEET COMP. ROOM A/C TAG ________

SECTION 15735 APPENDIX A, COMPUTER ROOM AIR CONDITIONING UNITS PRE-FUNCTIONAL TEST DATA SHEET

COMPUTER ROOM AIR CONDITIONING UNITS DATA				
	AS DESIGNED	**AS FOUND**	**ACTION REQUIRED**	**DONE**
MANUFACTURER				
MODEL NO.				
SERIAL NO.				
FAN HORSEPOWER.				
HUMIDIFIER MODEL				
REHEAT TYPE				
COOLING COIL ROWS/FINS				
MOTOR SHEAVE MANUF./MODEL				
FAN PULLEY MANUF./MODEL				
FILTERS: QTY / TYPE / SIZE				
MOTOR ANDCONTROLLER DATA COMPLETE FORM: SECTION 15051 APPENDIX A, MOTORS AND CONTROLLERS PRE-FUNCTIONAL TEST DATA SHEET				
INSTALLATION				
VIBRATION ISOLATION ADJUSTED?				
SHIPPING BLOCKS REMOVED?				
SEISMIC RESTRAINTS IN PLACE?				
COMPUTER ROOM A/C UNITS INSTALLED PROPERLY?				
FAN WHEEL & MOTOR INSTALLED AND MOUNTED PROPERLY AND ROTATE FREELY?				
STRAINERS IN PLACE & SCREEN CLEANED?				
FAN MOTORS LUBRICATED?				
HUMIDIFIER WATER PIPING INSTALLED?				
HUMIDIFIER DRAIN PIPING INSTALLED?				
CONDENSATE DRAIN PIPING INSTALLED WITH TRAP?				
FILTERS INSTALLED WITH NO AIR GAPS?				
DUCT COMPLETE AND SEALED?				
DUCT SUPPORTED INDEPENDENTLY FROM FAN?				
INLET/DSICHARGE DAMPERS INSTALLED CORRECTLY?				
PIPING COMPLETE AND TESTED?				
PIPING CONNECTED CORRECTLY AT COILS AND SUPPORTED INDEPENDENTLY FROM COMPUTER ROOM AIR CONDITIONING UNITS?				
LOCAL VALVING SET FOR NORMAL OPERATION?				
ELECTRICAL CONNECTIONS COMPLETE & TIGHT?				
DISCONNECT SWITCH INSTALLED?				
OVERLOAD HEATERS - MODEL & SIZE				

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________ Printed December 3, 2003

CRAC PRE-FUNCTIONAL TEST DATA SHEET COMP. ROOM A/C TAG ________

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________ Printed December 3, 2003

DUCT SYSTEM PRE-FUNCTIONAL TEST DATA SHEET DUCT SYSTEM TAG ________

SECTION 15180 APPENDIX A, DUCT SYSTEM PRE-FUNCTIONAL TEST DATA SHEET

DUCT SYSTEM DATA				
	AS DESIGNED	**AS FOUND/TESTED**	**ACTION REQUIRED**	**DONE**
DUCT MATERIAL				
INSULATION MATERIAL				
INSULATION THICKNESS				
LEAKAGE TEST PRESSURE				
PRESSURE TEST FAN Hz				
INSTALLATION				
SPRING HANGERS WHERE SPECIFIED?				
SEISMIC SUPPORTS INSTALLED PER SPEC'S				
LONGITUDINAL DUCT JOINTS SEALED?				
TRANSVERSE DUCT JOINTS SEALED?				
DUCT PENETRATIONS SEALED?				
FLEXIBLE DUCT CONNECTIONS INSTALLED PROPERLY?				
FLEXIBLE DUCTS INSTALLED WITH NO KINKS?				
MANUAL DAMPERS LEFT OPEN PRIOR TO BALANCE?				
DUCT PRESSURE TESTS PERFORMED AND PASSED?				
DUCT LEAKAGE TESTS PERFORMED AND PASSED?				

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________

TERMINAL UNIT PRE-FUNCTIONAL TEST DATA SHEET TERMINAL UNIT TAG ________

SECTION 15840 APPENDIX A, TERMINAL HEATING AND COOLING UNITS PRE-FUNCTIONAL TEST DATA SHEET

TERMINAL HEATING AND COOLING UNITS DATA				
	AS DESIGNED	AS FOUND	ACTION REQUIRED	DONE
MANUFACTURER				
MODEL NO. / SIZE				
SERIAL NO.				
VIBRATION ISOL MANUF.				
VIBRATION ISOLATION TYPE/DEFLECTION				
MOTOR AND CONTROLLER DATA COMPLETE FORM: SECTION 15051 APPENDIX A, MOTOR AND CONTROLLER PRE-FUNCTIONAL TEST DATA SHEET				
REHEAT COIL DATA				
	AS DESIGNED	AS FOUND	ACTION REQUIRED	DONE
ROWS				
CONTROL VALVE MANUF				
CONTROL VALVE MODEL #				
CONTROL VALVE SERIAL #				
CONTROL VALVE SIZE				
PIPE SIZE				
INSTALLATION				
VIBRATION ISOLATION ADJUSTED?				
SHIPPING BLOCKS REMOVED?				
SEISMIC RESTRAINTS IN PLACE?				
MOTOR INSTALLED AND MOUNTED PROPERLY AND ROTATE FREELY?				
FAN MOTOR LUBRICATED?				
DUCT COMPLETE AND SEALED?				
DUCT SUPPORTED INDEPENDENTLY FROM TERMINAL HEATING AND COOLING UNITS?				
INLET DUCT STRAIGHT FOR PROPER LENGTH				
PIPING & INSULATION COMPLETE AND TESTED?				
PIPING SUPPORTED INDEPENDENTLY FROM TERMINAL HEATING AND COOLING UNITS?				
PIPING VALVE & FITTING TRAIN AS SPEC’D				
LOCAL VALVING SET FOR NORMAL OPERATION?				
ELECTRICAL CONNECTIONS COMPLETE & TIGHT?				
DISCONNECT SWITCH INSTALLED?				
CONTROLS CONNECTED AND WIRED?				

AS FOUND CHECKED BY		DATE:	
REMEDIAL ACTION CHECKED BY		DATE:	

REMARKS:____

____

PAGE __________ OF ___________

Printed December 3, 2003