APPENDIX C

Engineering Design Criteria

C.1 Foundations and Civil
C.2 Seismic and Structural
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APPENDIX C.1

Foundations and Civil

APPENDIX C.1

FOUNDATIONS AND CIVIL ENGINEERING DESIGN CRITERIA

1.0 INTRODUCTION

The engineering, design, procurement, and construction activities of the Palmdale Hybrid Power Project will be in accordance with various predetermined standards and project-specific practices. This appendix summarizes the civil engineering codes, standards, design criteria, and practices that will be used during the design and construction. These criteria form the basis of the design for the foundations and civil systems of the project. More specific design information will be developed during the detailed design phase to support equipment procurement and construction specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

Manufactured equipment (e.g., turbines, compressors, heat recovery steam generators) will be purchased from quality, reputable manufacturers that normally supply equipment for the intended application in the electric power generating industry. The manufactured equipment and associated components and systems will be the manufacturer's standard supply for the application and will meet general industry accepted Codes and Standards applicable to that equipment. Manufactured equipment will not necessarily meet all the requirements of this section.

2.0 DESIGN CODES AND STANDARDS

The design, fabrication and construction shall be in accordance with all applicable laws and regulations of the federal government, the State of California, and the applicable local codes and ordinances. Except where noted otherwise, the latest issue of all codes and standards, including addenda, in effect at the start of the project will be used.

Manufactured equipment and associated components and systems will meet general industry accepted codes and standards applicable to that equipment.

The following summary of codes and standards, as applicable to power plants, will be followed for the civil design and construction of the plant, with the exception of manufactured equipment where the equipment manufacturer's requirements will govern:

2.1 GENERAL REQUIREMENTS

California Building Code (CBC), 2007 Edition as a minimum.

Specifications for materials will follow the standard specifications of the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI), unless noted otherwise.

Field and laboratory testing procedures for materials will follow ASTM standards.

Design and placement of structural concrete and reinforcing steel will be in accordance with the codes, guides, and standards of the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI).

Specifications for materials for road pavement will follow the State of California Department of Transportation Standard Specifications,

Design and construction of roads will follow the American Association of State Highway and Transportation Officials (AASHTO), the State of California Department of Transportation standards, and Kleinfelder's June 26, Preliminary Geotechnical Study, as applicable to site-specific facilities.

Design and construction of the sanitary sewer system inside buildings will conform to the Uniform Plumbing Code (UPC).

Welding procedures and qualifications for welders will follow the recommended practices and codes of the American Welding Society (AWS).

Preparation of metal surfaces for coating systems will follow the specifications and standard practices of the Steel Structures Painting Council (SSPC), National Association for Corrosion Engineers (NACE), and the specific instructions of the coatings manufacturer.

Design will conform to the requirements of the federal and California Occupational Safety and Health Administration (OSHA and Cal/OSHA).

Design of roof covering will conform to the requirements of the National Fire Protection Association (NFPA) and Factory Mutual (FM).

Other recognized standards will be used where required to serve as guidelines for design, fabrication, and construction.

2.2 GOVERNMENT RULES AND REGULATIONS

As applicable to specific project facilities, project civil engineering design and construction will comply with the following laws, ordinances, codes, and standards. In cases where conflicts between cited codes (or standards) exist, the requirements of the more stringent code will govern.

2.2.1 Federal

Title 29, Code of Federal Regulations (CFR), Part 1910, prescribes occupational safety and health standards.

Title 29, CFR, Part 1926, prescribes national safety and health regulations for construction National Pollutant Discharge Elimination System (NPDES) Title 33, United States Code (USC) Section 1342 et. seq. requires a permit for all discharges into navigable waters of the United States.

Title 40 CFR Sections 112 et seq., U.S. Environmental Protection Agency (U.S. EPA), requires a Spill Prevention Control and Countermeasure (SPCC) plan for facilities storing oil in excess of

660 gallons in any single aboveground storage tank; 1,320 gallons in aggregate tanks above ground; and 4,200 gallons below ground.

2.2.2 State

Business and Professions Code Section 6704, et seq.; Sections 6730 and 6736 requires state registration to practice as a Civil Engineer or Structural Engineer in California.

Labor Code Section 6500, et seq. requires a permit for construction of trenches or excavations 5 feet or deeper into which personnel have to descend. This also applies to construction or demolition of any building, structure, false work, or scaffolding that is more than three stories high or equivalent.

State of California Department of Transportation, Standard Specifications.

Title 8, CCR Section 1500, et seq.; Section 2300, et seq.; and Section 3200, et seq. Describes general construction safety orders, industrial safety orders, and work safety requirements and procedures.

Vehicle Code, Section 35780 et seq. requires a permit from Caltrans to transport loads in excess of highway weight limitations on state roads.

2.2.3 Local

City of Palmdale Design Standards, per the City of Palmdale Building and Safety Division.

- 2007 California Energy Code
- 2007 California Building Codes with Palmdale Amendments

2.3 INDUSTRY CODES AND STANDARDS

2.3.1 American Concrete Institute (ACI)

ACI 117	Standard Specification for Tolerances for Concrete Construction and Materials
ACI 211.1	Standard Practice for Selecting Proportions of Normal, Heavyweight, and Mass Concrete
ACI 301	Specifications for Structural Concrete for Buildings
ACI 302.1R	Guide for Concrete Floor and Slab Construction
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	Hot Weather Concrete
ACI 308	Standard Practice for Curing Concrete

ACI 309R Guide for Consolidation of Concrete

ACI 3I1.4R Guide for Concrete Inspection

ACI 318 Building Code Requirements for Reinforced Concrete

ACI 347R Guide to Formwork for Concrete

2.3.2 American Society for Testing and Materials (ASTM)

ASTM A82 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement -

ASTM A116 Standard Specification for Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric

ASTM AI2I Standard Specification for Zinc-Coated (Galvanized) Steel Barbed Wire

ASTM A185 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

ASTM A392 Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric

ASTM A6I5 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field

ASTM C33 Standard Specification for Concrete Aggregates

ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C76 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

ASTM C94 Standard Specification for Ready-Mixed Concrete

ASTM CI09 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in, or 50-mm Cube Specimens)

ASTM CI36 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM C 138 Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete

ASTM C143 Standard Test Method for Slump of Hydraulic Cement Concrete

ASTM CI50 Standard Specification for Portland Cement

ASTM C172 Standard Practice for Sampling Freshly Mixed Concrete

ASTM C231 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

ASTM C260 Standard Specification for Air-Entraining Admixtures for Concrete

ASTM C289 Standard Test Method for Potential Reactivity of Aggregates (Chemical Method)

ASTM C443 Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets

ASTM C478 Standard Specification for Pre-cast Reinforced Concrete Manhole Sections

ASTM C494 Standard Specification for Chemical Admixtures for Concrete

ASTM C586 Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks For Concrete Aggregates (Rock Cylinder Method)

ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan or Use as a Mineral Admixture in Portland Cement Concrete

ASTM C 1064 Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete

ASTM C1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout Nonshrink)

ASTM D422 Standard Test Method for Particle-Size Analysis of Soils

ASTM D1557 Moisture Density Relations of Soil and Soil Aggregate Mixtures Using 10-Pound (4.54-kg) Hammer and 18-Inch (4.57-mm) Drop.

ASTM DI556 Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D1752 Standard Specification for Preformed Sponge Rubber and Cork

ASTM D22I6 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock

ASTM D2922 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

ASTM D30I7 Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

ASTM D3034 Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings

ASTM D3740 Standard Practice for Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

ASTM E329 Standard Specification for Agencies Engaged in the Testing and/or inspection of Materials Used in Construction

2.3.3 Concrete Reinforcing Steel Institute (CRSI)

- Manual of Standard Practice

3.0 CIVIL DESIGN CRITERIA

3.1. NATURAL PHENOMENON

The climatological data listed were obtained from the National Oceanic and Atmospheric Administration Atlas 14 (NOAA, 2007) for the Palmdale Hybrid Power Project site (34.638 N 118.1144 W). The detail design will be based on the latest available data at the start of the project.

3.1.1 Rainfall

Maximum 24-Hour (25-Year): 2.88 inches

Maximum 24-Hour (100-Year): 3.75 inches

Maximum Monthly: 7.5 inches

The rainfall design basis may vary for the different systems and system components. Precipitation amounts and intensities to be used with each design basis for various durations and return periods will be obtained from the City of Palmdale Design Standards.

3.2 FOUNDATIONS

3.2.1 General

Geotechnical exploration, testing, and analysis determine the most suitable bearing methods for foundations. Criteria will be established to permit design of the most economical foundation that is compatible with the life expectancy and service of the structure.

The results of the preliminary subsurface investigation, laboratory testing program, and geotechnical assessment for the proposed site are presented in Appendix B, Preliminary Geotechnical Investigation Report. Based upon these preliminary results, it is anticipated that the existing subgrade, compacted fill, and the underlying rock will provide adequate allowable bearing pressures to allow the use of shallow foundations for all plant structures. This will need to be confirmed with additional geotechnical investigation prior to final foundation type selection.

3.2.2 Foundation Design Criteria

Foundation design criteria are included in Appendix B, Preliminary Geotechnical Investigation Report.

Detailed foundation design criteria, including allowable bearing pressures, will be developed based on the results of additional subsurface investigations performed during the detailed design phase of the project. Allowable bearing pressures will include a safety factor of at least 3 against bearing failures.

3.2.3 Equipment Foundations

Each piece of equipment will be supplied with a reinforced concrete foundation suitable to its operation. There the equipment could induce excessive vibration; the foundation will be provided with adequate mass to dampen vibratory motions. Special consideration will be given to vibration and stiffness criteria where specified by an equipment manufacturer.

Minimum reinforcement will be provided to comply with requirements for temperature and shrinkage reinforcing as required by Code and will be increased for structural requirements. Anchor bolts designed to develop their yield strength will be provided for critical equipment. For non-critical or lightly loaded equipment, concrete expansion, epoxy grouted, or other suitable anchors may be utilized to secure equipment to foundations.

Each foundation will be designed to resist the loadings furnished by the manufacturer plus loadings from natural phenomena and structural framing, if applicable, and will be constructed of reinforced concrete.

3.2.4 Rotating Equipment Foundations

Dynamic behavior will be considered in the design of foundations subjected to significant rotating equipment loads such as foundations for the combustion turbines, steam turbines, and the boiler feedwater pumps. A dynamic analysis will be performed to determine the natural frequencies and dynamic responses of the foundation. To account for soil and structure interaction, geotechnical data will be used to determine the soil stiffness and damping coefficients used in the dynamic analysis.

Dynamic responses will satisfy the equipment manufacturer's criteria and/or industry standards in terms of maximum velocity/displacement amplitudes that are considered acceptable for machine and human tolerances. To avoid resonance during machine operation, the resonant frequency of the foundation will typically be less than 80 percent or greater than 120 percent of the machine operating speed.

3.2.5 Equipment Seismic Requirements

When equipment is available that meets the seismic criteria for the site, it will be specified and the design will proceed based on the project-specific seismic requirements.

3.3 DESIGN LOADS

3.3.1 General

Design loads for structures and equipment foundations are discussed in Appendix C.2. Design loads for pavements and buried items will be determined according to the criteria described below, unless the applicable building code requires more severe design conditions.

3.3.2 Truck Loads

Loads exerted on roadway pavements, buried piping, electrical duct banks, and culverts will be reviewed and selected prior to design of the underlying items. As a minimum, these items will be designed for HS2O-44 loadings in accordance with AASHTO Standard Specifications. Loadings exceeding the HS2O-44 loadings will be considered where found applicable during the detailed design phase.

A surcharge load of 250 psf will be applied to plant structures accessible to truck traffic.

3.4 SITE

3.4.1 Site Arrangement

The site arrangement will conform to all applicable laws, regulations, and environmental standards. The principal elements to be considered in selection of the site arrangement are the physical space requirements and relationships dictated by each of the major plant systems, and the constraints imposed by the physical size and existing topography of the site, and subsurface materials. Distances from the main plant to various systems will be minimized for economy. However, adequate clearance between various plant systems will be provided as needed for construction, operations, maintenance, and fire protection. The plant will be configured to minimize construction costs and visual impacts while remaining operationally effective. Utility interconnections will be optimized.

3.4.2 Site Preparation

Site preparation will consist of clearing and grubbing, the excavation of soils and rock to design grade, and the preparation of fill slopes and embankments designed in such a fashion as to be stable and capable of carrying anticipated loads from either equipment or structures. Site preparation criteria are included in Appendix B, Preliminary Geotechnical Investigation Report. Clearing and grubbing, as well as mass grading and final grading of the site will be performed as part of this project.

3.4.3 Earthwork

Earthwork criteria are included in Appendix B, Preliminary Geotechnical Investigation Report.

Excavation

Excavation work will consist of the removal, storage, and/or disposal of earth, sand, gravel, vegetation, organic matter, loose rock, boulders, and debris to the lines and grades necessary for construction.

Materials suitable for backfill will be stored in stockpiles at designated locations using proper erosion protection methods. Other excess noncontaminated material will be used in the site development or removed from the site and disposed of at an acceptable location. Disposal of contaminated material if encountered during excavation will comply with all applicable federal, state, and local regulations.

All excavation and trenching operations will comply with local, state, and federal OSHA regulations and the recommendations of the geotechnical report

Grading and Embankments

Graded areas will be smooth, compacted, free from irregular surface changes, and sloped to drain.

Cut and fill slopes for permanent embankments will be designed to withstand horizontal ground accelerations for Seismic Zone 4 and per the Geotechnical report.

Cut and fill criteria are included in Appendix B, Preliminary Geotechnical Investigation Report.

Backfilling and Compaction

Backfilling and compaction criteria are included in Appendix B, Preliminary Geotechnical Investigation Report.

3.4.4 Site Drainage

The site drainage system will be designed to comply with all applicable federal, state and local regulations. Onsite drainage will be accomplished by gravity flow, whenever possible. The surface drainage system will consist of mild slopes and open channels. The ground floor elevation of buildings and structures will be maintained at a minimum of 6 inches above the finished grade. The graded areas away from structures will be at a minimum slope of 1 percent.

Design of the site drainage facilities will be performed in accordance with the City of Palmdale Design Standards. Drainage facilities will be designed for the flow resulting from a 25-year, 24-hour rainfall event. They will also be designed to prevent flooding of permanent plant facilities and overflow of plant roads resulting from a 100-year, 24-hour rainfall event. The flow of storm water from the site will be designed to generally follow the existing flow.

Runoff from possible oil and chemical contamination areas, such as the lube-oil storage area, transformer areas, and chemical storage areas, will be contained, and when released, routed through an oil/water separator and then discharged to the sanitary sewer system.

Ditches

Open channels and ditches generally will be trapezoidal in cross section, of sufficient width to facilitate cleaning, and mildly sloping so that erosion of the ditch bottom due to high flow velocities is minimized. Side slopes on ditches will be approximately 2:1 (horizontal: vertical) unless soil conditions dictate otherwise. The slope of the ditch bottom will generally be 1

percent, with a minimum slope of 0.5 percent. In areas where space is limited and design flow rates are small, ditches having a V-shaped cross section may be provided.

Ditches will be designed to carry the 25-year, 24-hour rainfall runoff with nonerosive velocities for the ditch construction material.

Culverts

Drainage culverts, if required, will be provided for passage of surface drainage under roads or embankments. Culverts will be constructed of reinforced concrete or corrugated metal pipe.

Culverts will be designed to convey the 25-year, 24-hour rainfall peak runoff. Cover provided under roads will be as required for truck wheel loads in accordance with Section 3.3.2. Minimum cover will be 12 inches.

Erosion and Sedimentation Control

The proposed site development will alter the land surface of the site. Existing vegetation will be removed during site preparation operations. This will be followed by the earthwork activities required for construction of specific facilities. Final finish grading will begin when all other earthwork operations are complete.

Erosion and sedimentation control will be provided to retain sediment on site and prevent violations of water quality standards. Permanent erosion and sedimentation control measures within the plant site will include the runoff collection system (e.g., ditches, inlets, culverts, drainage piping) and surfaced traffic and work areas. Final grading will include pavement aggregate surfacing of the entire plant site except for landscaped areas. These measures will minimize the possibility of any appreciable erosion, and the resulting sedimentation, from occurring on the site. Solar field surfacing will consist of compacted dirt.

Temporary erosion and sediment control measures that comply with state and local requirements will be utilized during the construction phase.

3.4.5 Roads

Access to the plant site will be from Avenue M, on the north border of the plant to the asphalt paved loop road that encircles the power plant. The access road from Avenue M will also be asphalt paved. The road will be 24 feet wide with a 4-foot shoulder on each side.

All other plant roads will generally be a minimum of 20 feet in width with an asphalt surface, except that if site space limitations require narrower roads, asphalt roads may be a minimum of 12 feet wide. The permanent parking area adjacent to the administration/control building will be paved with asphalt.

The longitudinal slope of roads will not exceed 7 percent. The crown or transverse slope will be 2 percent. The minimum radius to the inside edge of roads will be 30 feet where possible.

3.4.6 Fencing and Security

Chain-link security fencing will be provided around the facility site, substation, and other areas requiring controlled access. Fencing heights will be in accordance with applicable codes and

regulatory requirements. Controlled access gates will be located at the entrances to secured areas.

3.4.7 Sanitary Wastewater System

The sanitary wastewater system will collect sanitary wastewater from the facility and discharge to the Los Angeles Sanitation District, via a 12 inch sewer line. The Project will connect at an existing manhole located immediately north of E. Avenue L along 10th Street E./Challenger Way.

3.4.8 Spill Protection

Spill containment measures will be provided for chemical storage tanks and chemical additive/lube oil skid areas. The secondary containment dikes surrounding each tank will be designed to contain the tank volume plus additional volume to contain a 25-year, 24-hour rainfall event to account for precipitation. In the project vicinity, 10 percent excess capacity can be used to approximate such a rainfall event. Concrete curbs will be provided for chemical additive/lube oil skid areas. Where required for protection of the containment structure, appropriate surface coatings will be provided.

3.4.9 Geotechnical Investigation

The Preliminary Geotechnical Investigation Report for the Palmdale Hybrid Power Project site is included as AFC Appendix B.

4.0 METEOROLOGICAL AND CLIMATIC HAZARD MITIGATION

The project will be designed to mitigate natural and environmental hazards caused by meteorological events. This section addresses the civil design criteria used to mitigate such hazards.

Meteorological and climatic data were used to establish the project design basis. Portions of the data and the design bases that pertain to civil engineering are provided in this appendix.

Specific design features that will be incorporated into the plant to mitigate meteorological and climatic hazards include:

- Site drainage systems will be designed to convey the runoff from a 24-hour rainfall event with a 25-year recurrence interval.
- Ground floor levels of structures will be placed above probable flood levels.
- The bases of plant equipment will be placed above probable flood levels.
- The plant site will be graded to convey runoff away from structures and equipment.
- Potentially collapsible soils will be removed and recompacted and other measures designed to prevent foundation soil saturation will be implemented as needed to eliminate the potential for soil collapse due to hydrocompaction.

The foregoing design features will be incorporated in accordance with the applicable codes and standards identified in this appendix.

The degree of safety offered by these features is consistent with the requirements of the applicable codes and standards and the economic benefits these features provide.

APPENDIX C.2

Seismic and Structural

APPENDIX C.2

STRUCTURAL AND SEISMIC ENGINEERING DESIGN CRITERIA

1.0 INTRODUCTION

Palmdale Hybrid Power Project design, engineering, procurement, and construction activities will be in accordance with various predetermined standards and project-specific practices. This appendix summarizes the structural and seismic engineering codes and standards, design criteria, and practices that will be used during design and construction. These criteria form the basis for the project structural design work. More specific design information will be developed during detailed design to support equipment procurement and construction specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

Section 2 summarizes the applicable codes and standards, and Section 3 includes the general criteria for natural phenomena, design loads, materials, seismic design, and architecture. Section 5 describes the structural design methodology for structures and equipment. Section 6 addresses project hazard mitigation.

Manufactured equipment (e.g., turbines, compressors, heat recovery steam generators) will be purchased from quality, reputable manufacturers that normally supply equipment for the intended application in electric power generating industry. The manufactured equipment and associated components and systems will be the manufacturer's standard supply for the application, and will meet general industry accepted Codes and Standards applicable to that equipment. Manufactured equipment will not necessarily meet all the requirements of this section.

2.0 DESIGN CODES AND STANDARDS

Work will be designed and specified in accordance with applicable laws and regulations of the federal government and the State of California, and applicable local codes and ordinances, based on the location of the site. Except where noted otherwise, the latest issue of codes and standards, including addenda, in effect at the start of the project will be used. The codes and standards including addenda, in effect at the time of purchase will be used for material and equipment procurement.

Manufactured equipment and associated components and systems will meet general industry accepted codes and standards applicable to that equipment.

The following summary of codes and standards, as applicable to power plants, will be followed for the structural design and construction of the plant, with the exception of manufactured equipment, where the equipment manufacturer's requirements will govern.

2.1 GENERAL REQUIREMENTS

Work will be designed and specified in accordance with applicable laws and regulations of the federal government and the State of California, and applicable local codes and ordinances, based on the location of the site. Except where noted otherwise, the latest issue of codes and standards, including addenda, in effect at the start of the project will be used. The codes and standards, including addenda, in effect at the time of purchase will be used for material and equipment procurement.

A summary of the codes and the standards to be used in design and construction follows:

- Seismic standards and criteria will follow the 2007 California Building Code (CBC) and ASCE 7 "Minimum Design Loads for Buildings and Other Structures", based on the location of the site.
- Specifications for materials will follow the standard specifications of the American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI), unless noted otherwise.
- Field and laboratory testing procedures for materials will follow ASTM standards.
- Structural concrete and reinforcing steel will be designed and placed in accordance with the codes, guides, and standards of the American Concrete Institute (ACI) and the Concrete Reinforcing Steel Institute (CRSI).
- Structural steel will be designed, fabricated, and erected in accordance with the American Institute of Steel Construction (AISC) Manual of Steel Construction.
- Steel components for metal wail panels and roof decking will conform to the American Iron and Steel Institute (AISI) Specification for the Design of Cold- Formed Steel Structural Members.
- Welding procedures and qualifications for welders will follow the recommended practices and codes of the American Welding Society (AWS).
- Metal surfaces for coating systems will be prepared following the specifications and standard practices of the Steel Structures Painting Council (SSPC) and the specific instructions of the coatings manufacturer.
- Masonry materials will be designed and erected in accordance with the ACI Building Code Requirements for Masonry Structures.
- Roof covering design will comply with the requirements of the National Fire Protection Association (NFPA) and Factory Mutual (FM).
- Design and construction will conform to the applicable federal and California Occupational Safety and Health Administration (OSHA and CAL-OSHA) requirements.

Other recognized standards will be used where required to serve as guidelines for design, fabrication, and construction.

2.2 GOVERNMENT RULES AND REGULATIONS

The following laws, ordinances, codes, and standards are applicable to structural design and construction. In cases where conflicts between cited codes (or standards) exist, the requirements of the more stringent code will govern. The sections in the 2007 California Building Code (CBC) have been quoted throughout this document as reference.

The 2007 CBC will apply to the engineering design.

2.2.1 Federal

- Title 29, Code of Federal Regulations (CFR), Part 1910, Prescribes occupational safety and health standards.
- Title 29, CFR, Part 1926, National Safety and Health regulations for construction.

2.2.2 State

- Business and Professions Code Section 6704, et seq., Sections 6730 and 6736. Requires state registration to practice as a Civil Engineer or Structural Engineer in California.
- Labor Code Section 6500, et seq. requires a permit for construction of trenches or excavations 5 feet or deeper into which personnel have to descend. This also applies to construction or demolition of any building, structure, false work, or scaffolding that is more than three stories high or equivalent.
- Title 8, CCR Section 1500, et seq.; Section 2300, et seq.; and Section 3200, et seq. describes general construction safety orders, industrial safety orders, and work safety requirements and procedures.

2.2.3 Local

- City of Palmdale Design Standards, per the City of Palmdale Building and Safety Division.
    - 2007 California Mechanical Code
    - 2007 California Building Codes with Palmdale Amendments

2.3 INDUSTRY STANDARDS

2.3.1 American Concrete Institute (AC1)

ACI 117	Standard Specification for Tolerances for Concrete Construction and Materials
ACI 211.1	Standard Practice for Selecting Proportions of Normal, Heavyweight, and Mass Concrete
ACI 301	Specifications for Structural Concrete for Buildings
ACI 302.1R	Guide for Concrete Floor and Slab Construction
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	Hot Weather Concreting
ACI 308	Standard Practice for Curing Concrete

ACI 309R Guide for Consolidation of Concrete

ACI 311.4R Guide for Concrete Inspection

ACI 318 Building Code Requirements for Reinforced Concrete

ACI 318.1 Building Code Requirements for Structural Plain Concrete

ACI 347R Guide to Formwork for Concrete

ACI 530 Building Code Requirements for Masonry Structures

ACI 530.1 Specifications for Masonry Structures

2.3.2 American Iron and Steel Construction (AISC)

- Code of Standard Practice for Steel Buildings and Bridges
- Manual of Steel Construction, 13th Edition.
- Specification for Structural Steel Buildings
- Specification for Structural Joints Using ASTM A325 or A490 Bolts.

2.3.3 American Iron and Steel Institute (AISI)

- Specification for the Design of Cold-Formed Steel Structural Members.

2.3.4 American Society for Testing and Materials (ASTM)

ASTM A36 Standard Specification for Structural Steel

ASTM A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A82 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement

ASTM AI06 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

ASTM A108 Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality

ASTM A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM AI 85 Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

ASTM A240	Standard Specification for Heat-Resisting Chromium and Chromium-Nickel stainless, Steel Plate, Sheet, and Strip for Pressure Vessels
ASTM A276	Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes
ASTM A307	Standard Specification for Carbon Steel Bolts and Studs. 60,000 psi Tensile Strength
ASTM *A325*	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/1 05 ksi Minimum Tensile Strength
ASTM A446	Standard Specification for Steel Sheet, Zinc-Coated Galvanized) by the Hot-Dip Process, Structural (Physical) Quality
ASTM A500	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A501	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A569	Standard Specification for Steel, Carbon *(0.15* Maximum. Percent), Hot-Rolled Sheet and Strip Commercial Quality
ASTM A615	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM B695	Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
ASTM C3 I	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C90	Standard Specification for Load-Bearing Concrete Masonry Units
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or 50-mm Cube Specimens)
ASTM C129	Standard Specification for Non-Load-Bearing Concrete Masonry Units
ASTMCI36	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

ASTM Cl38 Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete

ASTM C143 Standard Test Method for Slump of Hydraulic Cement Concrete

ASTMC 150 Standard Specification for Portland Cement

ASTM C172 Standard Practice for Sampling Freshly Mixed Concrete

ASTM C23l Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method

ASTM C260 Standard Specification for Air-Entraining Admixtures for Concrete

ASTM C270 Standard Specification for Mortar for Unit Masonry

ASTM C289 Standard Test Method for Potential Reactivity of Aggregates (Chemical Method)

ASTM C494 Standard Specification for Chemical Admixtures for Concrete

ASTM C586 Standard Test Method for Potential Alkali Reactivity of Carbonate Rocks for Concrete Aggregates (Rock Cylinder Method)

ASTM C1064 Standard Test Method for Temperature of Freshly Mixed Portland Cement
Concrete

ASTM Cl107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)

ASTM D1752 Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

ASTM E329 Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

ASTM C6 18 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.

2.3.5 American Society of Mechanical Engineers (ASME)

ASME, VIII Boiler and Pressure Vessel, Rules for Construction of Pressure vessels, Division 2 Alternative Rules

ASME/STS-l Steel Stacks.

2.3.6 American Society of Civil Engineers (ASCE)

ASCE 7 Minimum Design Loads for Buildings and Other Structures.

2.3.7 American Water Works Association (AWWA)

AWWA DI00 Welded Steel Tanks for Water Storage.

2.3.8 American Welding Society (AWS)

AWS DI.1 Structural Welding Code - Steel

AWS DI .4 Structural Welding Code - Reinforcing Steel.

2.3.9 California Energy Commission

- Recommended Seismic Design Criteria for Non-Nuclear Generating Facilities in California.

2.3.10 Concrete Reinforcing Steel Institute (CRSE)

- Manual of Standard Practice.

2.3.11 Metal Building Manufactures Association (MISMA)

- Low Rise Building Systems Manual.

2.3.12 National Fire Protection Association (NFPA)

NFPA 22 Standard for Water Tanks for Private Fire Protection

NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NFPA 80 Standard for Fire Doors and Fire Windows

NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants

2.3.13 Steel Structures Painting Council (55W)

- Steel Structures Painting Manual, Volume 2, Systems and Specifications

3.0 STRUCTURAL DESIGN CRITERIA

3.1 NATURAL PHENOMENA

The design criteria based on natural phenomena are discussed in this section.

3.1.1 Wind Speed

Based on data from the National Climatic Data Center (NCDC, 1998), the maximum wind gusts occur in winter. The basic wind speed for design purposes will be based on the site location per

the 2007 CBC and ASCE 7. The basic wind speed will be used to determine the wind loads on structures, as discussed in Section 5.

3.1.2 Temperature

The following temperature data was obtained from the National Oceanic and Atmospheric Administration (NOAA, 2000):

Maximum: 113° F
Minimum: 6° F
Annual Average 63° F

3.1.3 Relative Humidity

Based on data from the National Oceanic and Atmospheric Administration (NOAA, 2000), the mean afternoon annual relative humidity in the project area ranges from 16 to 39 percent.

3.1.4 Seismicity

The plant site is located in Seismic Zone 4, as determined from 2007 CBC and ASCE 7 based on the plant site location.

- Mapped Spectral Response Acceleration Parameters, S_s = 1.503; S_1 = 0.709
- Site Coefficients, F_a = 1.0; F_v = 1.5
- Seismic Importance Factor, I = 1.25
- Site Class = D
- Occupancy Category III
- Seismic Design Category D

3.1.5 Snow

The ground snow load shall be based on the plant site location per 2007 CBC and ASCE 7 provisions.

3.2 DESIGN LOADS

3.2.1 Dead Loads

Dead loads include the weight of all components forming the permanent parts of structures and all permanent equipment. The dead load of permanent plant equipment will be based on actual equipment weights. For major equipment, structural members and foundations will be specifically located and designed to carry the equipment load into the structural system. For equipment weighing less than the uniform live load, the structural system will be designed for the uniform live load.

The contents of tanks and bins at full operating capacity will be considered as dead loads. The contents of tanks and bins will not be considered effective in resisting uplift due to wind forces but will be considered effective for seismic forces.

A uniform load of 50 psf will be used to account for piping and cable trays, except in administration building areas, and will be carried to the columns and foundations as dead loads.

Uniform piping and cable tray loads will not be considered effective in resisting uplift due to wind forces, but will be considered effective for seismic forces. Additional piping loads will be considered in the design of areas with heavy piping concentrations. After critical and/or heavy piping hanger loads and locations are established, the supporting members will be reviewed for structural adequacy.

For pipe racks, the weight of piping and cable trays will be treated as live load.

3.2.2 Live Loads

Live loads are the loads superimposed by the use and occupancy of the building or structure. They do not include wind loads, snow loads, or seismic loads.

Uniformly distributed live loads will be included to provide for movable and transitory loads, such as the weight of people, office furniture and partitions, portable equipment and tools, and other nonpermanent materials. These uniform live loads will not be applied to floor areas permanently occupied by equipment, with no access beneath. Uniform live loads for equipment laydown areas will be based on the actual weight and size of the equipment and parts that may be temporarily placed on floors during dismantling, maintenance, installation, or removal.

The design live loads will be as follows:

- **Ground Floor (Grade Slab)**

  A uniform load of 250 psf, nonpermanent equipment weights, storage weights, or laydown weights, whichever is greater, will be used.

- **Grating Floors, Platforms, Walkways, and Stairs**

  A uniform live load of 100 psf will be used. In addition, a concentrated load of 2 kips will be applied concurrently to the supporting beams to maximize stresses in the members, but the reactions from the concentrated load will not be carried to columns. Maximum deflection of the grating will be limited to 1/200 of the span.

- **Elevated Concrete Slabs**

  A uniform load of 100 psf, nonpermanent equipment weights, storage weights, or laydown weights, whichever is greater, will be used.

  Elevated concrete slabs will be designed to support either the prescribed live load or a single concentrated load of 2 kips, whichever produces the greater stresses. The concentrated load will be treated as a uniformly distributed load acting over an area of 2.5 square feet and will be located to produce the maximum stress conditions in the slab.

  Metal decking for concrete slabs will be designed for a load during construction equal to the weight of concrete plus 50 psf (no increase in allowable stress).

- **Roof**

  Roof areas will be designed for a minimum live load of 20 psf. Ponding loading effect due to roof deck and framing deflections will be investigated in accordance with Section K2 of the AISC Specification for Structural Steel Buildings. Allowable Stress Design and Plastic Design.

- **Pipe Racks**

  A minimum uniform load of 100 psf will be used for each level of the pipe racks, except that where piping and cable tray loads exceed 100 psf, the actual loads will be used. In addition, a concentrated load of 5 kips will be applied concurrently to the supporting beams to maximum stresses in the members, but the reactions from the concentrated loads will not be carried to columns.

- **Truck Loads**

  A surcharge load of 250 psf will be applied to plant structures accessible to truck traffic.

  Roads pavements, underground piping, conduits, sumps, and foundations subject to truck traffic will be designed for wheel loadings in accordance with Appendix C. 1. Section 3.3.2.

- **Thermal Forces**

  Thermal forces caused by thermal expansion of equipment and piping under all operating conditions will be considered.

- **Dynamic Loads**

  Dynamic toads will be considered and applied in accordance with the manufacturer's criteria/recommendations and industry standards.

3.2.3 Wind Loads

Wind loads for structures and their components will be determined in accordance with the CBC, using a basic wind speed based on the location of the site. Category and an Importance Factor shall be used and also based on the location of the site per 2007CBC and ASCE 7.

3.2.4 Seismic Loads

Seismic loads will be determined in accordance with the requirements specified in Section 3.4.

3.2.5 Other Loads

Other expected loads required to predict the structural response of structures would be considered where appropriate (i.e., water hammer, test loads, etc.).

3.2.6 Load Combinations

Applicable code prescribed load combinations will be considered in the design of structures. As a minimum, the following load combinations will be considered:

- Dead load
- Dead load + live load + operating loads
- Dead load + live load + operating loads + wind load
- Dead load + live load + operating loads + seismic load
- Dead load + construction loads
- Dead load + live load + emergency loads
- Dead load + wind load
- Dead load + seismic load

Operating loads include all loads associated with normal operation of the equipment (e.g., temperature and pressure loads, piping loads, normal torque loads, impact loads, etc.).

3.2.7 Strength Requirements

Each load combination will not exceed the stress or strength levels permitted by the appropriate code for that combination.

3.2.7.1 Concrete Structures

The required strength (U) of concrete structures will be at least equal to the following:

- U = 1.4 (Dead+Fluid)
- U = 1.2 (Dead+Fluid+Temperature) + 1.6 (Live+Soil) + 0.5(Roof Live or Snow or Rain)
- U = 1.2 Dead + 1.6 (Roof Live or Snow or Rain) + (1.0 Live or 0.8 Wind)
- U = 1.2 Dead + 1.6 Wind + 1.0 Live + 0.5 (Roof Live or Snow or Rain)
- U = 1.2 Dead + 1.0 Seismic + 1.0 Live + 0.2 Snow
- U = 0.9 Dead + 1.6 Wind + 1.6 Soil
- U = 0.9 Dead + 1.0 Seismic + 1.6 Soil

3.2.7.2 Steel Structures

The required strength (5) based on elastic design methods defined in the AISC Specification for Structural Steel Buildings, will be at least equal to the following.

For Allowable Stress Design (without 1/3 increase for wind or seismic loading):

- S = Dead
- S = Dead + Live
- S = 0.75 (Dead + Wind)
- S = 0.75 (Dead + Seismic)
- S = 0.75 (Dead + Live + Wind)
- S = 0.75 (Dead + Live + Seismic)

For Load and Resistance Factor Design:

- U = 1.2 Dead + 1.6 (Roof Live or Snow or Rain) + (1.0 Live or 0.8 Wind)
- U = 1.2 Dead + 1.6 Wind + 1.0 Live + 0.5 (Roof Live or Snow or Rain)
- U = 1.2 Dead + 1.0 Seismic + 1.0 Live + 0.2 Snow
- U = 0.9 Dead + 1.6 Wind + 1.6 Soil
- U = 0.9 Dead + 1.0 Seismic + 1.6 Soil

For load combinations including seismic loading, frame members and connections will conform to the additional requirements of the CBC.

3.2.8 Factors of Safety

Minimum factors of safety for structures, tanks, and equipment supports will be as follows:

- Overturning 1.50
- Sliding 1.50 for seismic load
  1.50 for wind load
- Buoyancy 1.25
- Uplift due to wind 1.50

3.3 MATERIALS

3.3.1 Structural Steel

Structural steel will conform to ASTM A36, ASTM A992, ASTM AS72 or other materials as required and accepted for use by the referenced AISC Specifications.

High-strength bolts for connections will conform to ASTM A325 or ASTM A490. Connection bolts other than high- strength bolts will conform to ASTM A307; Grade A. Nonheaded anchor bolts will conform to ASTM A36 or ASTM F1554, unless higher strength bolting materials are required by design. Drilled in expansion bolts for concrete will be Hilti-Kwik Bolts or equivalent. All exposed connection and anchor bolts shall be galvanized.

Structural steel will be detailed and fabricated in accordance with the AISC Code of Standard Practice and the AISC Specification for Structural Steel Buildings. Structural material will be fabricated and assembled in the shop to the greatest extent possible. Structural members will be welded in accordance with AWS DI.1. Columns will be milled to bear on the base plate or cap plate. Connections will have a minimum of two bolts.

Exterior structural steel will be either hot-dip galvanized or shop primed and finish painted after installation. Interior structural steel will be shop primed after fabrication. Surface preparation and painting will be in accordance with Steel Structures Painting Council standards. Galvanizing will be in accordance with the requirements of ASTM standards.

3.3.1.1 Design and Testing

Steel structures will be designed by the Working Stress Method (ASD) or Limit States Method (LRFD) in accordance with the CBC and the AISC Specification for Structural Steel Buildings.

Connections will be in accordance with the AISC Manual of Steel Construction and the AISC Specification for Structural Joints Using ASTM *A325* or A490 Bolts.

Steel structures will be designed as "rigid frame" (AISC Specification Type 1) or "simple framing" (AISC Specification Type 2), using single-span beam systems, vertical diagonal bracing at main column lines, and horizontal bracing at the roof and major floor levels.

Type I rigid frames will be generally limited to prefabricated metal buildings. All other framed structures will use Type 2 design and construction.

Metal roof and floor decking attached with appropriate welding or fasteners may be considered effective as horizontal diaphragms, provided the manufacturer previously qualifies them. Grating floors will not be considered as providing horizontal rigidity.

Mill test reports or certificates of conformance will be required certifying that material is in conformance with the applicable ASTM specification. In addition, the fabricator will be required to provide an affidavit stating that steel has been furnished in accordance with the requirements of the drawings and the specifications, including specified minimum yield strength.

3.3.1.2 Handrails, Guardrails and Toe Plates.

Handrails and/or guardrails, except for pre-engineered equipment, will be fabricated from standard weight steel pipe and fittings, either galvanized or painted. Handrails will have toe plates where there is no curb.

3.3.1.3 Steel Grating and Grating Stair Treads.

The steel to be used for grating and grating treads will conform to either ASTM A36 or ASTM A569. Grating will be rectangular and consist of welded steel construction. Grating will be hot-dip galvanized after fabrication.

Stair treads will have nonslip abrasive nosing and will have end plates for attaching to stringers. Outdoor grating will have a serrated surface.

The Hilti Grating Disk system, or equivalent, will be used for fastening. Grating will have at least a 1-inch bearing support.

Floor and platform openings necessitated by expansion and movement requirements around piping and equipment will be protected as follows:

- Openings exceeding 1-1/2 inches wide around penetrating objects will be protected by toe plates.
- Openings exceeding 8 inches wide around penetrating objects will be protected by toe plates and handrails.

3.3.1.4 Stairs and Ladders

Stairs and ladders shall conform as a minimum to OSHA standards unless more stringent requirements are required per CBC. Stairs will be the means of travel from one elevation to

another. Vertical ladders, ship ladders, etc. will be installed only where personnel access is infrequent base on prior owner's approval.

Fixed ladders will have safety cages and/or other fall-prevention devices as required by the applicable codes and regulations. Stairs will, have handrails on both sides.

3.3.2 Concrete and Reinforcing Steel

3.3.2.1 General

Materials for concrete will comply with ACI 301. Cement will be Portland cement meeting the requirements of ASTM CI50. Fine aggregates will be clean natural sand. Coarse aggregates will be crushed stone or gravel. Aggregates will conform to the chemical and physical requirements of ASTM C33. Only clean water of potable quality and satisfying the requirements of ASTM C94 will be used.

Admixtures such as plasticizers and retarders may be used to improve workability and control setting time. Concrete will have an entrained air content between 3 and 6 percent by volume. Air entraining admixtures will meet ASTM C260 requirements. Water reducing admixtures will conform to ASTM C494, Type A. Calcium chloride or admixtures containing calcium chloride will not be used.

Concrete reinforcing will be deformed bars of intermediate grade billet steel conforming to ASTM A615, Grade 60 ASTM A706, or welded wire fabric conforming to ASTM A 185.

3.3.2.2 Design

Reinforced concrete structures will be designed by the Ultimate Strength Method in accordance with the CBC and ACI 318, Building Code Requirements for Reinforced Concrete.

3.3.2.3 Concrete Mix Design

Concrete mix designs will be proportioned and furnished in accordance with ACI 211.1, ASTM C94, and CBC. Proportions for the concrete mixture will be selected to meet the strength requirements specified in design documents. Generally, a minimum concrete compressive strength of 4000 psi at 28 days will be required for structural concrete Final concrete mix designs will be established based on historical strength performance data or trial mixtures meeting the requirements of the CBC.

3.3.2.4 Testing and Material Certification

Certified mill test reports on chemical and physical properties confirming compliance with ASTM C150 will be required for each shipment of cement used.

Certificates of Conformance will be obtained from the supplier certifying that aggregates used comply with the chemical and physical requirements of ASTM C33. Gradation analyses of fine and coarse aggregates, performed in accordance with ASTM CI36, will also be provided.

Manufacturer will certify that the admixture provided conforms to the specified ASTM standard and that it contains no chlorides except those that may be contained in the water used in manufacturing the admixture.

The slump, air content, and temperature of the concrete at the point of discharge from the conveying vehicle will be tested in accordance with specified minimum testing frequencies. Concrete strength will be evaluated in accordance with ASTM C94 and CBC.

Mill test reports certifying that reinforcing steel is in accordance with ASTM and project specifications will be required.

3.4 SEISMIC DESIGN CRITERIA

This section provides the general criteria and procedures to be used for the seismic design of buildings, structures, and structural components.

When equipment is available that meets the seismic criteria for the site, it will be specified and the design will proceed based on the project-specific seismic requirements.

3.4.1 Seismic Performance Objectives

The seismic performance objectives for this facility are:

- Resist minor levels of earthquake ground motion without damage
- Resist moderate levels of earthquake ground motion without structural damage, but with some nonstructural damage
- Resist major levels of earthquake ground motion without collapse, but with some structural as well as nonstructural damage

To achieve these objectives and to meet the requirements of the California Energy Commission (CEC) and local codes, the facility will be designed in accordance with the CBC.

3.4.2 General Criteria

For seismic load calculations, the Importance Factor for Category III structures (power plants) shall be based on the 2007 CBC (Table 1604.5). Accordingly, an Importance Factor of 1.25 will be used for all plant buildings, structures, and structural components, except special use structures requiring higher Importance Factors.

Buildings and structures conforming to CBC will be designed using the static lateral force procedure of CBC and ASCE 7 and the Geotechnical report recommendations. Nonbuilding structures will be designed in accordance with CBC and ASCE 7 and the Geotechnical report recommendations.

Buildings and structures conforming to CBC will be designed using the dynamic lateral force procedure of CBC and ASCE 7 and the Geotechnical report recommendations. The ground motion representation used will be the elastic design response spectrum constructed in accordance with CBC and ASCE 7.

Lateral forces on elements of structures and nonstructural components supported by structures will be determined in accordance with CBC and ASCE 7 requirements.

Water storage tanks will meet the seismic design requirements of AWWA D100, Appendix C.2.

3.4.3 Critical Structures

Critical structures are those structural components that are necessary for power production and are costly to repair or replace or that require a long lead time to repair or replace; or are used for the storage, containment, or handling of hazardous or toxic materials.

Seismic loads for critical structures will be determined by the static lateral force procedure of the CBC.

4.0 ARCHITECTURE

4.1 GENERAL

Architectural work will be in accordance with the applicable laws, ordinances, codes and industry standards, design criteria, guidelines, general requirements, and material selection specified in this section.

The plant will be laid out to accommodate the spaces required for plant equipment and operations. Aisles and clearances will provide access for operation, minor maintenance, and equipment removal. Personnel walkways to equipment (for routine maintenance only), doors, stairs, and other access points will be provided. Plant security and life safety features will also be considered in the plant layout.

4.2 CRITERIA

These criteria are intended to govern the architectural design of structures and facilities.

Safety, construction, fire protection and firewalls, and requirements for the physically handicapped will be in accordance with the requirements of the applicable local, state, and national codes and standards. Requirements of the Americans with Disabilities Act will also be included in the design.

Generally, plant buildings will be single-story, pre-engineered metal, with insulated siding. For sloping roofs, roofing will be standing seam metal with insulation and a vapor barrier; for flat roofs; roofing will be single-ply membrane over metal decking with insulation.

The administration/control building will include control room, men's and women's toilet, locker room and shower facilities. Library, conference room, lunchroom, offices, and utility rooms.

The control room, offices, library, lunchroom, corridors, conference room, and toilet locker areas will have suspended acoustical ceilings. Electrical rooms and HVAC equipment spaces will have exposed structure.

Reinforced concrete grade slabs will be treated with a sealer and/or floor hardener, as applicable, to accommodate maintenance or laydown. Interior wall partitions will be concrete block masonry, concrete, or gypsum wallboard on metal studs. Stairs will be concrete, galvanized grating, or checkered plate. Floor drains will be provided as necessary.

4.3 MATERIALS

Asbestos- and lead-containing materials will not be used in the facility.

4.3.1 Concrete Masonry

Concrete masonry unit (CMU) partitions will generally be used in traffic and spillage areas, in toilets and locker rooms, in the battery and electrical rooms, and as fire boundaries where required by code.

CMU will be both hollow, normal weight, nonload-bearing Type I conforming to ASTM C 129, and load-bearing Grade N, Type I conforming to ASTM C 90. Mortar will conform to ASTM C 270; Type M. CMU will be reinforced as required.

Masonry structures will be designed and constructed in accordance with ACI 530, Building Code Requirements for Masonry Structures; ACI 530:1, Specifications for Masonry Structures; and of the CBC.

4.3.2 Preformed Metal Siding

Exterior siding will be either an insulated or an uninsulated field-assembled system. Exterior face panels will be 24-gauge minimum; interior face panels will be 22-gauge minimum. Panels will be fabricated from galvanized sheet steel.

The wall system will be designed to withstand the specified wind loading with practical and economical support girt spacing.

Wall insulation will be noncombustible glass fiber to produce a maximum U-factor of 0.08 Btu/hr/ft^2/°F.

4.3.3 Metal Studwall Partitions

Except when CMU partitions are required ceiling-height interior partitions will generally be of metal stud and painted gypsum board construction.

4.3.4 Roofing

Roofing will be either single-ply membrane over rigid insulation board, mechanically fastened to the metal roof deck, or standing seam metal with insulation and vapor barrier. The completed roofing system will conform to UL requirements for Class A roofs and to Factory Mutual wind uplift Class 90. The completed roof will have an overall maximum U- factor of 0.05 Btu/hr/ft^2/°F.

4.3.5 Metal Roll-Up Doors

Roll-up doors will have insulated door curtains constructed of interlocking roll-formed galvanized steel slats to withstand the specified wind pressure. Doors will be manually operated.

4.3.6 Reflow Metal Doors, Frames and Hardware

Personnel doors will be flush hollow metal on pressed steel doorframes, with hinges, lockers, closets, weather-stripping, and accessory hardware. Fire doors and frames will conform to NFPA 80 for the class of door furnished.

4.3.7 Louvers

Louvers will be operable, extended aluminum section alloy, with stainless steel fastenings and removable aluminum bird screen. Blades will be storm-proof. Louver free area will be a minimum of 50 percent of louver face area. Louvers will be designed for manual or gravity operation.

4.3.8 Floor Finish

Floor finishes will generally be concrete with curing and sealing protection.

The battery room and other chemical areas will generally receive special coatings.

4.4 PAINTING

Generally, exposed wall surface, structures, and structural components will be prime painted or otherwise treated to protect them from corrosion in accordance with the applicable codes, industry standards, and manufacturer's recommendations. In addition, the power plant structures and the equipment in the adjacent switchyard will have a flat, neutral, gray-tan finish that will blend with the local natural environment.

4.4.1 Structural and Miscellaneous Steel

Interior structural and miscellaneous steel will receive shop-applied inorganic zinc primer. All exterior structural and miscellaneous steel will be hot-dipped galvanized. Field touchup will be performed after erection. Structural steel requiring fireproofing will either receive no painting or a primer compatible with the selected fireproofing material.

4.4.2 Masonry Walls and Concrete Walls and Floors

Concrete floors in areas not exposed to chemical contaminants will not be coated. Indoor masonry walls in areas requiring paint but not exposed to chemical contaminants will be painted with one coat of acrylic filler and a compatible finish coat.

4.4.3 Gypsum Wallboard

Exposed surfaces will receive one coat each of sealer and compatible acrylic finish.

5.0 STRUCTURAL DESIGN METHODOLOGY

This section describes the structural aspects of the design of the proposed facility. Each major structural component of the plant is addressed by defining the design criteria and analytical techniques that will be employed.

5.1 EQUIPMENT FOUNDATIONS

This section describes design and installation of foundations for combustion and steam turbines, heat recovery steam generator and stacks.

Each foundation will be designed to resist the loadings furnished by the manufacturer plus loadings from natural phenomena and structural framing, if applicable, and will be constructed of reinforced concrete.

5.1.1 Foundation Loads

Equipment foundation loads will be furnished by the combustion and steam turbine manufacturer and will be combined with the other loads imposed on the foundation. Typical loading data supplied by the manufacturer include the following:

- Dead loads.
- Live loads.
- Wind loads.
- Seismic loads.
- Normal torque loads.
- Normal machine unbalance loads.
- Emergency loads, such as turbine accident or generator short-circuit.
- Thermal loads due to thermal expansion or contraction of the machines, connected piping, and turbine pedestal components.
- Shrinkage and creep loads.
- Condenser vacuum load (steam turbine only).

5.1.2 Induced Forces

The equipment will be securely anchored to their foundations using cast-in-place steel anchor bolts designed to resist the equipment forces and seismic or wind loads.

5.1.3 Structural System

Based on preliminary geotechnical information, equipment foundation systems will consist of a reinforced concrete mat bearing directly on undisturbed soil, or compacted fill. The steam turbine generator will be provided with a reinforced concrete rigid frame pedestal and a reinforced concrete mat bearing directly on undisturbed soil, or compacted fill. The condenser for the steam turbine will be located below the turbine on the turbine foundation mat. Foundation types (mat or deep), especially for the steam turbine, will be confirmed following more detailed geotechnical investigations.

Refer to Kleinfelder, Inc.'s preliminary Geotechnical Evaluation, File No. 82300 dated April 11, 2007 (Appendix B) for finding relative to the suitability of the subsurface conditions at the project site which is located on the northwest side of the Palmdale Air Force Base, Plant 42 in Palmdale, CA.

5.1.4 Structural Criteria

Each foundation will be designed and constructed as a monolithic reinforced concrete structure using the criteria from Section 3 and Appendix C.I, Section 3.2. The foundation design will address the following considerations:

- Allowable bearing pressures.
- Allowable settlements.
- Equipment, structure, and environmental loads.
- Factors of safety against overturning and sliding.
- Equipment performance criteria.
- Natural frequencies and dynamic effects of rotating equipment.
- Access and maintenance.

Bearing pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor against bearing failure as specified in Appendix C.I, Section 3.2.2. Total and differential settlements will be limited to acceptable levels.

Environmental loadings will be determined in accordance with Sections 3.1 and 3.2. Wind loads will be applicable since the equipment will not be housed in an enclosed building. Foundation seismic loading will be calculated as specified in Section 3.4. Seismic forces will be applied at the center of gravity of the equipment.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3.2.6 and 3.2.7. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

5.1.5 Analytical Techniques

Computer analysis will be used for both static and dynamic loads on the steam turbine pedestal and foundation. The pedestal deck and columns will be modeled as 3-dimensional (3-D) space frame structure using 3-D beam elements. The foundation mat will be modeled using 3-D plate bending elements.

The interaction between the mat and supporting soil or other bearing material will be modeled using a system of vertical and horizontal springs attached to a fixed boundary.

Static analyses will be performed to obtain structure displacements and internal forces and moments produced by the static portion of the load combinations, including seismic loads.

Dynamic analyses will be performed to confirm the adequacy of the pedestal and foundation to support the operating machinery and sustain the dynamic loads associated with machinery operation within specified displacement and stress limits. Dynamic analyses may not be required where the effects of particular dynamic loads are specified by the manufacturer in terms of equivalent static loads.

Mat foundations will be designed using static analysis techniques. If adequate rigidity is provided, the mats will be analyzed as a rigid mat foundations to determine the resulting bearing

pressures and internal forces and moments. The foundations will be analyzed assuming a linear soil pressure distribution.

If its rigidity is in question, the foundation mats will be considered as flexible systems and modeled as a plate structures using 3-D plate bending elements. The interaction between the mats and supporting bearing material will be modeled using a system of vertical and horizontal springs attached to a fixed boundary. A computer analysis will be performed using finite element techniques.

The foundation will be checked for dynamic response to the operating turbine. A dynamic analysis will typically be performed by considering the mat foundation as rigid and using a lumped mass model. The lumped mass model will include bearing material springs and dashpots to account for bearing material and structure interaction. An analysis will be performed to determine the natural frequencies of the foundation using the lumped mass model. In the case when the rigidity of the mat foundation is in question. The mat will be considered as flexible and will be modeled by plate elements, and a dynamic analysis will be performed using finite element computer analysis.

To avoid resonance during machine operation, the resonant frequency of the foundation will typically be less than 80 percent or greater than 120 percent of the machine operating speed.

5.2 BUILDINGS AND ENCLOSURES

The various plant buildings and enclosures will provide support, protection, and access to the systems contained within their boundaries. Generally, each building and enclosure will be one story and pre-engineered. Each building and enclosure will be securely anchored to its foundation using cast-in-place steel anchor bolts designed to resist any induced forces.

5.2.1 Foundation Loads

Foundation loads will be determined from the analysis and design of the superstructure and from the support of the equipment contained within the structure. The following loads will be considered:

- Dead loads.
- Live loads.
- Equipment and piping loads.
- Wind loads.
- Seismic Toads.

5.2.2 Induced Forces

Each building and enclosure will be securely anchored to its foundation using cast-in-place steel anchor bolts designed to resist any induced forces.

5.2.3 Structural System

Buildings and enclosures will be designed as AISC Type 1 rigid frames or as Type 2 simple braced frames. For the purpose of resisting seismic lateral loads, the structures will be classified

as regular structures with a concentric braced frame, an ordinary moment-resisting frame, or a special moment-resisting frame, in accordance with the definitions of the CBC.

The foundation systems for buildings and enclosures will typically consist of individual spread footings to resist the column loads, and an isolated slab-on-grade floor system.

5.2.4 Structural Criteria

Building and enclosure steel frames will be designed and constructed using the materials and criteria set forth in Section 3.

Environmental loading will be determined in accordance with Sections 3.1 and 3.2. Seismic loading for the buildings and enclosures will be calculated using equivalent static lateral forces applied to the structure in accordance with the procedures of CBC and ASCE 7.

Building and enclosure foundations will be designed and constructed using reinforced concrete according to the criteria set forth in Section 3 and Appendix C.1, Section 3.2. The foundation design will address the following considerations:

- Allowable bearing pressures.
- Allowable settlements
- Equipment, structure, and environmental loads.
- Factors of safety against overturning and sliding.
- Equipment performance criteria.
- Access and maintenance.

Bearing pressures will satisfy the allowable bearing pressure criteria that will be developed during project detailed design to provide a minimum safety factor indicated in Appendix C.1, Section 3.2.2. Total and differential settlements will be limited to acceptable levels.

Load combinations and their respective strength requirements for the foundation design will be as indicated in Sections 3 2.6 and 3.2.7. Factors of safety against overturning and sliding will satisfy the requirements of Section 3.2.8.

5.2.5 Analytical Techniques

Building and enclosure foundations will be designed as simple spread footings or mat foundations, using static analysis techniques. The foundations will be analyzed assuming a linear bearing pressure distribution.

5.2.6 Tanks

Storage tanks will typically be vertical, cylindrical shells consisting of carbon steel construction with a protective interior coating. Tank roofs will be either self-supported domes or cones. Tank bottoms will be ground-supported, flat-bottomed, with a slope of 1 percent. Tanks will have ladders to provide access to 'the top for maintenance. Vents, manholes, overflow piping, and grounding lugs will be provided as necessary.

Storage tanks will be securely anchored to their foundations using cast-in-place steel anchor bolts designed to resist tank-induced forces. Each tank will be a cylindrical steel shell that

resists lateral loading through shear in the tank wall. Overturning will be resisted by anchor bolts connecting the tank wall to the foundation.

Tank structures will be designed and proportioned such that during the application of any load, or combination of loads, the allowable stresses as stipulated in AWWA DI00 are not exceeded.

The project will comply with Foundation design and installation criteria described in Section C.5, Equipment Foundations.

6.0 HAZARD MITIGATION

The project will be designed to mitigate natural and environmental hazards caused by seismic and meteorological events. This section addresses the structural design criteria used to mitigate such hazards.

6.1 SEISMIC HAZARD MITIGATION CRITERIA

Appendix C.I and this appendix describe the civil and structural design criteria that will be applied to the project. Project seismic design criteria were selected based on the following considerations:

- Compliance with applicable laws, ordinances, regulations, codes, and standards.
- Life safety.
- Structural behavior and performance.
- Reliability of the plant.
- Financial impacts from seismically induced outages.
- Seismic probability and magnitude.

The project seismic design criteria were developed to incorporate these considerations using a systematic approach to correlate performance criteria with assumed risk level. The following procedure was used to establish the design criteria:

- The seismic hazards were assessed by studying the geologic features of the surrounding area. Major faults were identified, and information was collected regarding each fault's proximity, capability, recurrence, and magnitude.
- The seismic risk associated with each source was assessed considering historical magnitudes.
- Site seismic parameters will be considered for structural design per the CBC based on the location of the site.
- When using the dynamic lateral force procedure, acceleration levels for various structural frequencies will be based on ASCE Figure 11.4-1, Design Response Spectra
- Appropriate design criteria and analysis methods consistent with the seismic performance criteria were established for each major plant structure, equipment, and component.
- Specific design features that will be incorporated into the plant to mitigate the identified seismic hazards include:
- Appropriate analysis techniques will be employed to calculate structure-specific seismic loads.

- Plant structures, equipment, piping, and other components will be designed to resist the project-specific seismic loads.
- Critical equipment will be positively anchored to its supporting structure.
- Anchorages will be designed to resist project-specific seismic loadings.
- Adequate factors of safety against overturning and sliding due to seismic loads will be provided.
- The design of piping connections to structures, tanks, and equipment will consider differential seismic displacements between components.
- Adjacent structures will be seismically isolated from one another.
- Structural elements will be designed to comply with special detailing requirements intended to provide ductility.
- Connections for steel structures will have a minimum load carrying capability without regard to the calculated load.
- Lateral and vertical displacements of structures and elements of structures will be limited to specified values.
- Appropriate measures will be taken to prevent saturation of foundation soils and eliminate the potential for soil liquefaction.

The foregoing design features are intended to provide the degrees of safety for structures and equipment as follows:

- Resist minor earthquakes without damage. Plant remains operational.
- Resist moderate earthquakes without structural damage but with some non-structural damage. Plant remains operational or is returned to service following visual inspection and/or minor repairs.
- Resist major earthquakes without collapse but with some structural and nonstructural damage. Plant is returned to service following visual inspection and/or moderate repairs.

6.2 METEOROLOGICAL AND CLIMATIC HAZARD MITIGATION

Meteorological and climatic data were used to establish the project design basis. Portions of the data and the design bases that pertain to structural engineering are provided in this appendix.

Specific design features that will be incorporated into the plant to mitigate meteorological and climatic hazards include.

- Structures and cladding will be designed to resist the wind forces.
- Sensitive structures will be designed for wind-induced vibrational excitation.
- Roofs will be sloped and equipped with drains to prevent accumulation of rainfall.
- Building drain lines will be installed with backflow prevention devices.

The foregoing design features will be incorporated in accordance with the applicable codes and standards identified in this appendix.

The degree of safety offered by these features is consistent with the requirements of the applicable codes and standards and the economic benefits these features provide.

APPENDIX C.3

Mechanical

APPENDIX C.3

MECHANICAL ENGINEERING DESIGN CRITERIA

1.0 INTRODUCTION

This appendix summarizes and supplements key mechanical design standards, methods, and other pertinent general design elements of the Palmdale Hybrid Power Project. The design criteria are the general basis for design of project mechanical systems and components.

Manufactured equipment (e.g., turbines, compressors, heat recovery steam generators) will be purchased from quality, reputable manufacturers that normally supply equipment for the intended application in the electric power generation industry. The manufactured equipment and associated components and systems will be the manufacturer's standard supply for the application, and will meet general industry-accepted Codes and Standards applicable to that equipment. Manufactured equipment will not necessarily meet all the requirements of this section.

2.0 DESIGN CODES AND STANDARDS

Mechanical engineering design will be in accordance with applicable laws and regulations of the State of California and the Federal Government and applicable local codes and ordinances. Except where noted otherwise, the latest issue of codes and standards, including addenda, in effect at the start of the project will be used. When no other codes or standards govern, the latest revision of the Uniform Building Code (UT3C) and the applicable sections of California Building Code (CBC) at the start of the project will govern. The sections in UBC have been quoted throughout this document as reference. These sections are based on the 1997 edition of UBC. However, the latest edition of UBC and the applicable sections of CBC at the start of the project will apply to the engineering design. Pertinent parts of the following documents that are applicable to power plant mechanical engineering design criteria are summarized in this appendix.

2.1 FEDERAL

- Code of Federal Regulations (CFR)

CFR Title 29	Occupational Safety and Health Administration (OSHA)
40 CFR, Part 60	Standards of Performance for New Stationary Sources, Specifically Subpart GG, New Source Performance Standards (NSPS) for Gas Turbines
40 CFR, Subchapter C	Air Programs, 50 et seq.
40 CFR, Subchapter D	Water Programs, 100 et seq.

40 CFR, Subchapter I Solid Waste, 260 et seq. Hazardous

40 CFR Subchapter N Effluent Guidelines & Standards, 400 et seq

2.2 STATE OF CALIFORNIA

- California Code of Regulations (CCR) 8 Industrial Safety, General Construction Safety Orders, Industrial Safety Orders, and work Safety Requirements and Procedures.

  14 Natural Resources

  17 Public Health

  19 Public Safety

  20 Public Utilities & Energy

  22 Social Security, Minimum Standards for Management of Hazardous & Extremely Hazardous Waste

  23 Waters

  24 California Building Code; prescribes the use of UBC, UMC, and UPC and provide special building regulations (Part 6)

  26 Toxic

- California Administrative Code, Title 8

  Chapters 4 through 7 Groups 20 Flammable Liquids, Gases, and Vapors

  Chapter 27 Fire Protection

- California Business and Professional Code

  Section 6704 Requires state registration to practice engineering.

  Section 6735 Requires that all plans, specifications, reports, or documents prepared by a registered engineer, or by a subordinate under his/her direction, be signed by the registered engineer to indicate responsibility for them.

- California Building Code (CBC)
- Uniform Building Code (UBC)
- California Fire Code (CFC)
- Uniform Mechanical Code (UMC)
- California Plumbing Code (CPC)

2.3 INDUSTRY CODES AND STANDARDS

- Air Moving and Conditioning Association (AMCA)

Publication	201 Fans and Systems
Publication	203 Field Performance Measurements
Standard	2402 Drive Arrangements for Centrifugal Fans

- American Boiler Manufacturers Association (ABMA)
  Standards for Steam Quality

- American Gas Association (AGA)

- American Gear Manufacturers Association (AGMA)

- American Iron and Steel Institute (AISI)

- American National Standards Institute (ANSI)

  Various standards for piping and pipefittings, valves, etc

ANSI B 133.7M	Gas Turbine Fuels
ANSI B 133.8	Gas Turbine Installation Sound Emissions

- American Petroleum Institute (API)

- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

- American Society of Mechanical Engineers (ASME)

ASME Section I	Rules for Construction of Power Boilers
ASME Section II	Material Specifications
ASME Section V	Nondestructive Examination
ASME Section VIII	Rules for Construction of Pressure Vessels
ASME Section IX	Welding and Brazing Qualifications
ASME B31.1	Power Piping
ASME B 1.7	Gas Piping
ASME PTC 4.4	Heat Recovery Steam Generators
ASME PTC 6.2	Interim Test Code for an Alternative Procedure for testing Steam Turbines

ASME PTC-22 Gas Turbine Power Plants

ASME PTC-23 Atmospheric Water-Cooling Equipment

- American Society for Nondestructive Testing (ASNT)
- American Society of Sanitary Engineers (AS SE
- American Society of Civil Engineers (ASCE)
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)

  Structural Welding Code, DI.1
- American Water Works Association (AWWA)

  Standard for Welded Steel Tanks for Water Storage
- Compressed Gas Association (CGA)

  CGA G-2. I Safety Requirements for the Storage and Handling of Aqueous Ammonia
- Cooling Tower Institute (CTI) Standard Specification

  Standard Specification for the Design of Cooling Towers
- Ductile Iron Pipe Research Association
- Expansion Joint Manufacturers Association (EJMA)
- Factory Mutual Engineering Corporation (FM); Loss prevention data
- Fluid Controls Institute (FCI)
- Heat Exchange Institute (HEI)
- Hydraulic Institute (HI)
- Illuminating Engineering Society (IFS)
- Institute of Electrical and Electronics Engineers (IEEE)
- Instrument Society of America (ISA)
- U.S Department of Defense Military Specification (MIL Spec)

- Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA) Codes

  10 Portable Fire Extinguishers
  13 Installation of Sprinkler Systems
  14 Installation of Standpipe Systems
  15 Water Spray Fixed Systems
  20 Installation of Centrifugal Fire Pumps
  22 Water Tanks for Private Fire Protection
  24 Installation of Private Fire Service Mains and their appurtenances
  30 Flammable and Combustible Liquids Code
  70 National Electric Code
  72 National Fire Alarm Code
  214 Water Cooling Towers
  231 Standard for General Storage
  255 Surface Burning Characteristics of Building Materials

- Pipe Fabrication Institute (PFI)
- Plastics Pipe Institute (PPI)
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
- Steel Structures Painting Council (SSPC)
- Thermal Insulation Manufacturers Association (TIMA)
- Tubular Exchanger Manufacturers Association (TEMA)
- Underwriters' Laboratories Inc. (UL)

3.0 MECHANICAL EQUIPMENT AND COMPONENTS

3.1 GENERAL REQUIREMENTS

When Equipment is available which meets the seismic criteria for the site it will be specified and the design will proceed based on the project specific seismic requirements

3.2 MATERIALS - GENERAL

Asbestos will not be used in the materials and equipment supplied for the facility. Where feasible, materials will be selected to withstand the design operating conditions, including expected ambient conditions, for the design life of the plant. It is anticipated that some materials will require replacement during the life of the plant due to corrosion, erosion, etc.

3.3 PROCESS PUMPS

Vertical shaft pumps will generally be arranged to work with the pump casing submerged in a sump or tank. The suction branch will be arranged vertically downward and, if required for the service conditions, will be fitted with a strainer. The pump shafts will be supported by more than one bearing on each side of the flexible coupling. The discharge piping and non- return valve will be arranged to facilitate withdrawing the complete shaft and pump casing as a unit by splitting a pipe joint above floor level.

Strainers (startup or permanent) will be installed in the suction piping of horizontal pumps or sets of pumps. Horizontal-shaft centrifugal pumps will have radially fully balanced impellers. The driver will be mounted on an extension of the pump bedplate and will drive the pump through a flexible coupling with OSHA coupling guard.

Pumps will operate satisfactorily when delivering varying quantities of fluid up to the maximum pump output. Pump motors will be sized so that the selected pump impeller will not overload the motor at any point on the pump head-capacity curve.

Pumps will be sized in accordance with the Contractor's standards. Where feasible, pumps will be selected for high efficiency at the normal operating point. Pumps will be free from excessive vibration throughout the operating range.

Where necessary, pumping systems with variable flow requirement will have a recirculation line for pump protection. The recirculation line will normally be routed to the source from which the system takes suction. Modulating or two-position automatic recirculation valves or restriction orifices will be used as applicable. For boiler feedwater pump and condensate pump, modulating automatic recirculation control valves or combined recirculation/check valves will be used.

Where necessary, vent and drain valves will be fitted at suitable points on the pump casing. Horizontal split case pumps will allow the removable half-casing and impeller to be withdrawn without disturbing any of the process piping or valves. Horizontal end-suction pumps will allow the impeller to be withdrawn from the motor end without disturbing the motor or discharge piping.

Pumps may have either packing or mechanical seals, as determined by the application. Pumps that have mechanical seals will be arranged to facilitate seal removal. Shaft slingers will be specified to prevent packing gland leakage water from entering the bearing housings.

Bearings will have ample surface area and, for large pumps, will be split for easy maintenance and arranged to facilitate removal of the pump impeller for repairs.

The inner faces of ball or roller bearings will be fitted directly onto the shaft and located by a machined shoulder on the shaft. For vertically suspended pumps, intermediate shaft bearings will be securely connected to the main pump support tube.

Bearings requiring cooling water will include the appropriate pipework, valves, and strainers. For vertical shaft fresh water or condensate pumps, bearings below water level will be water lubricated.

The weight of the impeller and shafting for vertically suspended pumps will be supported by a thrust bearing, and ample access will be provided for examination and maintenance.

Provisions will be made at each end of the bearing to prevent oil or grease from being thrown outside the bearing housing or creeping along the shaft.

Couplings and intermediate shafting will be guarded. Bedplates will be of ample proportions and stiffness to withstand the loads likely to be experienced in shipment and service.

3.4 TANKS

Field-erected water storage tanks will be designed, fabricated, erected, inspected, tested, and certified in accordance with ANSI/AWWA DI00. The demineralized water storage tank will be constructed of carbon steel with an internal coating. The fire/service water storage tank will be designed in accordance with NFPA 22.

Large outdoor storage tanks will be uninsulated. Overflow connections and lines will be provided. Maintenance drain connections will be provided for complete tank drainage. Manholes, where included, will be at least 18 inches in diameter and hinged to facilitate removal. Storage tanks will have ladders and cleanout doors as required to facilitate access/maintenance. Provisions will be included for proper tank ventilation during internal maintenance.

3.5 HEAT EXCHANGERS

The surface condenser will be designed in accordance with HEI standards. Other heat exchangers will be provided as components of mechanical equipment packages and may be shell-and-tube or plate type. Heat exchangers will be designed in accordance with TEMA or manufacturer's standards. Fouling factors will be specified in accordance with TEMA. As required, heat exchangers will have thermal relief valves.

3.6 PRESSURE VESSELS

Pressure vessels will be designed, fabricated, tested, and installed per ASME Code Section VIII and CCR Title 8, Chapter 4.

Pressure vessels will include the following features/appurtenances:

- Process, vent, and drain connections for startup, operation, and maintenance
- Materials compatible with the fluid being handled
- A minimum of one manhole and one air ventilation opening (e.g., handled) where required for maintenance or cleaning access
- Relief valves in accordance with the applicable codes

3.7 PIPING AND PIPING SUPPORTS

Stainless steel pipe may be Schedule 5 or 10 where design pressure permits. Underground piping may be high-density polyethylene (HDPE) where permitted by code, operating conditions,

and fluid properties. In general, water system piping will be HDPE where embedded or underground and carbon steel, ductile iron, or cast iron where above ground.

Piping systems containing steam will be of welded construction. Where flanges are required to connect to specific components, they will be raised face types, except for connections to cast iron components. Connections to cast iron components will use flat face flanges. Threaded joints will not be used in piping used for steam, and lube oil service. Natural gas piping components will not use synthetic lubricants. Where economical, Victaulic couplings may be used for low energy above ground piping.

Piping systems will have high point vents and low point drains. Drains with restricting orifices or steam traps with startup and blowdown drains and strainers/crud traps will be installed in low points of steam lines where condensate can collect during normal operation.

Condensate collection in piping systems will be avoided by installing automatic drain devices and manual devices as appropriate. Steam drain lines in the plant will be sloped at a minimum of 1/8" per foot. The Contractor reserves the right to alter this general design requirement if it becomes impractical to maintain strict adherence; however, the piping will still be designed to drain properly.

Steam lines that are fitted with restricting devices, such as orifices in the process runs, will be provided with adequate drainage upstream of the device to ensure that water does not collect in lines.

Means will be provided to fill and clean loop seals.

Hose and process tubing connections to Owner-furnished portable components and systems will be compatible with the respective equipment supplier's standard connections for each service.

Large-bore, shop-fabricated metal pipes requiring weld heat treatment during fabrication (except for onsite welding) will be completely cleaned after fabrication to remove grit and mill scale.

Piping, pipe supports, and pipe accessories will be designed to resist project-specific loads and loads from applicable codes and standards, and shall be in accordance with the criteria established in this appendix. Typical loading for a piping system includes:

- Dead loads
- Live loads
- Wind loads
- Seismic loads
- Temperature and pressure loads
- Steam and water hammer
- Test loads

The seismic loading and design of piping systems and pipe supports will be in accordance with project-specific criteria. Seismic analysis of piping and components will be in accordance with applicable codes.

Hangers and accessories shall use steel anchor bolts, fasteners, welds, and other pipe anchorage devices. All such pipe anchorages will be designed to resist induced forces. Structural supports required for piping will be designed using static analysis techniques. For all load combinations, including seismic, the stresses in the structural supporting members will remain in the elastic range. Structural allowable strengths will be as indicated for steel structures in Appendix C.2 Section 3.2.7.2.

3.8 VALVES

3.8.1 General Requirements

Valves will be arranged for convenient operation from floor level, where possible Elevated valves, not accessible from floor level and requiring actuation during normal operation, will have extension spindles, chain operators, or gearing, as required. Elevated valves, not accessible from floor level and not requiring actuation during normal operation will be made accessible with portable ladders or platforms.

Hand-actuated valves will be operable by one person. Manual valves 8 inches or larger will have gear operators. Valves will be arranged to close when the handwheel is rotated clockwise when looking at the handwheel from the operating position. The direction of rotation to close the valve will be clearly marked on the face of each handwheel, unless the valve position is intuitive (i.e., quarter turn valves). Critical valves will be remotely monitored for position. Valves operating at less than atmospheric pressure will have means to prevent air in-leakage.

Valve materials will be suitable for operation at the maximum working pressure and temperature of the piping to which they are connected. Steel valves will have cast or forged steel spindles. Seats and faces will be of low friction, wear-resistant materials. Valves in throttling service will be selected with design characteristics and of materials that will resist erosion of the valve seats when the valves are operated partly closed.

3.8.2 Drain, Vent Valves and Traps

Drains and vents in 900-pound class or higher piping and 800° F or higher service will be double-valved.

Drain traps will have air cock and easing mechanisms. Internal parts will be constructed from corrosion-resistant materials and will be renewable.

Trap bodies and covers will be cast or forged steel and will be suitable for operating at the maximum working pressure and temperature of the piping to which they are connected. Traps will be piped to drain collection tank or sumps and returned to the cycle if convenient.

3.8.3 Low Pressure Water Valves

Low pressure water valves will be of the butterfly, ball, globe or gate type constructed of suitable materials for the intended service. Fire protection valves will be UL approved and listed for fire protection service in accordance with NFPA requirements.

3.8.4 Instrument Air Valves

Instrument air valves will be the butterfly, bail or globe type, and constructed of suitable materials for the intended service.

3.8.5 Non-return Valves

Non-return valves for steam service will be in accordance with ANSI standards and properly drained. Non-return valves in vertical positions will have bypass and drain valves. Bodies will have removable access covers to enable the internal parts to be examined or renewed without removing the valve from the pipeline.

3.8.6 Motor-Actuated Valves

The use of valve motor actuators will be determined based on each valve's functional requirements, accessibility, size, operating environment, and frequency of operation. Motor actuators will have torque switches to stop the motor automatically when the valve gate has reached the "full open" or "full closed" position. The motor actuator will be placed in a position relative to the valve that prevents leakage of liquid, steam, or corrosive gas from valve joints onto the motor or control equipment. Motor actuators will have seating control consisting of a slipping clutch or other torque-limiting device that limits seating force to an acceptable level.

3.8.7 Safety and Relief Valves

Pressure vessels, heaters, and boilers will have safety valves and/or relief valves as required by code. Safety and relief valves will be installed vertically. Pressure relief valves will also protect piping systems that can be over-pressurized by a higher pressure source. Equipment or parts of equipment that can be over-pressurized by thermal expansion of the contained liquid will have thermal relief valves.

3.8.8 Instrument Root Valves

Instrument root valves will be specified for operation at the working pressure and temperature of the piping to which they are connected, Instrument taps in 900 pound class or higher and 800° F or higher steam service will be double-valved.

3.9 THERMAL INSULATION AND CLADDING

Parts of the facility will be thermally insulated to reduce heat loss or afford personnel safety. Insulation surfaces will be designed to limit heat loss to approximately 80 Btu per hour per square foot at 80° F ambient and at 3 mph air velocity. Emissivity is based on aluminum jacketing. The insulation criteria for personnel protection will be such that the temperature on the outside of the lagging does not exceed 140° F when the ambient temperature is 80° F and the air velocity is 3 mph.

Thermal and freeze protection insulation will have as its main constituent ceramic fiber, calcium silicate, foam glass, glass fiber, polyurethane, polyisocyanurate, or mineral wool, and will consist of preformed slabs or blankets, where feasible. Asbestos materials will be prohibited. An aluminum jacket or suitable coating will be provided on the outside surface of the insulation. Where a hard-setting compound is used, it will be nonabsorbent and non-cracking. Thermal insulation will be chemically inert even when saturated with water. Insulation system materials,

including jacketing, will have a flame spread rating of 25 or less when tested in accordance with ASTM E 84. Insulation system materials used inside buildings shall have a density rating of 50 or less when tested in accordance with ASTM F 84. Insulation at valves, pipe joints, steam traps, or other points to which access may be required for maintenance will be removable with a minimum of disturbance to the pipe insulation. At each flanged joint, the molded material will terminate on the pipe at a distance from the flange equal to the overall length of the flange bolts to permit their removal without damaging the molded insulation. Steam trap stations will be "boxed" for ease of trap maintenance and freeze protection.

Above ground, insulated piping will be clad with pebbled or corrugated aluminum of not less than 0.02-inch thickness and frame reinforced. At the joints, the sheets will be sufficiently overlapped and corrugated and caulked to prevent moisture from penetrating the insulation.

Design temperature limits for thermal insulation will be based on system operating temperature during normal operation.

Any piping which is subject to freezing during plant operation will be heat traced and/or insulated for freeze protection during shutdown.

4.0 HEATING, VENTILATING, AND AIR-CONDITIONING

Heating, ventilating, and air-conditioning (HVAC) systems will be designed and installed in accordance with the applicable Codes and Standards.

Design conditions for normally occupied areas such as the control room, offices, and toilet rooms are as follows:

- Summer 78° F dry bulb. 65 percent relative humidity
- Winter 70° F dry bulb

Because HVAC systems bring filtered outside air into control rooms and offices, the interior pressure is greater than atmospheric pressure. Any air that moves through the openings around doors or windows or elsewhere moves from the higher pressure (inside) to the lower pressure (outside). HVAC system filter efficiency for rooms containing computer equipment is expected to be approximately 80 percent, thereby controlling dust contamination in these areas. HVAC system filter efficiency for generally occupied areas will be in accordance with ASHRAE STD-62.

Except for the HVAC systems serving the control room and administration areas, the systems will not be designed to provide comfort levels for extended human occupancy. The temperature of indoor facilities that are not air conditioned will be maintained at ambient plus 10° F in summer and a minimum of *55*° F in winter.

Air conditioning will include both heating and cooling of the filtered inlet air. Air velocities in ducts and from louvers and grills will be low enough not to cause unacceptable noise levels in areas where personnel are normally located.

Fans and motors will be mounted on anti-vibration bases to isolate them from the building structure. Exposed fan outlets and inlets will be fitted with guards. Wire guards will be specified for belt-driven fans and arranged to enclose the pulleys and belts.

Air filters will be housed in a way that facilitates removal. Filter frames will pass the air being handled through the filter without leakage

Ductwork, filter frames, and fan casings will be constructed of mild steel sheets stiffened with mild steel flanges and galvanized. Ductwork will be the sectional bolted design and adequately supported. Duct joints will be leaktight.

Grills and louvers will be of adjustable metal construction.

5.0 TESTING

Hydrostatic testing, including pressure testing at *1.5* times the design pressure, will be specified and performed for pressure boundary components where an in-service test is not feasible or permitted by code. Pneumatic test may be performed.

6.0 WELDING

Welders and welding procedures will be certified in accordance with applicable codes and standards before performing any welding.

The Contractor will maintain indexed records of welder qualifications and weld procedures.

7.0 PAINTING

Except as otherwise specified, equipment will receive the respective manufacturer's standard shop finish. Finish colors will manufacturer's standard. Finish painting of uninsulated piping and equipment will otherwise be limited to that required by OSHA for safety or for protection from the elements.

Piping to be insulated will not be painted.

8.0 LUBRICATION

The types of lubrication will be suited to plant operating conditions and will comply with the recommendations of the equipment manufacturers.

The initial charge of flushing oil for startup will be manufactures standard lubricant for the intended service. Subsequently, such flushing oil will be sampled and analyzed to determine whether it can also be used for normal operation or it will be replaced in accordance with the equipment supplier's recommendations.

Rotating equipment will be splash lubricated, force lubricated, or self-lubricated. Oil cups will be provided as necessary. Where applicable, equipment will be designed for manual lubrication while the equipment is in operation without the removal of protective guards. Lubrication filling and drain points will be readily accessible.

APPENDIX C.4

Control Systems

APPENDIX C.4

CONTROL SYSTEMS ENGINEERING DESIGN CRITERIA

1.0 INTRODUCTION

Palmdale Hybrid Power Project design, engineering, procurement, and construction activities will be controlled in accordance with various predetermined standard practices and project-specific programs and practices.

This appendix summarizes the codes and standards and standard design criteria and practices that will be used during the project. The general control systems design criteria defined herein form the basis of the design for the control systems of the project. More specific design information will be developed during detailed design to support equipment and installation specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize this information.

Manufactured equipment (e.g., turbines, compressors, heat recovery steam generators) will be purchased from quality, reputable manufacturers that normally supply equipment for the intended application in the electric power generation industry. The manufactured equipment and associated components and systems will be the manufacturer's standard supply for the application, and will meet general industry-accepted Codes and Standards applicable to that equipment. Manufactured equipment will not necessarily meet all the requirements of this section.

2.0 DESIGN CODES AND STANDARDS

The design specifications for all work are in accordance with the applicable laws and regulations of the Federal Government and the State of California and applicable local codes and ordinances.

The following summary of codes and standards, as applicable to power plants, will be followed for the controls design and construction of the plant, with the exception of manufactured equipment, where the equipment manufacturer's requirements will govern:

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Materials (ASTM)
- Institute of Electrical and Electronics Engineers (IEEE)
- Code of Federal Regulations, 40 CFR 60, Protection of Environment
- Electronics Industries Association (EIA)
- Instrument Society of America (ISA)
- Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National. Fire Protection Association (NFPA)
- Underwriters Laboratories Inc. (UL)

The codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including addenda, in effect as stated in equipment and construction purchase or contract documents.

2.1 General Seismic Requirements

When equipment is available that meets the seismic criteria for the site, it will be specified and design will proceed based on the project-specific seismic requirements.

3.0 CENTRALIZED CONTROL AND DEGREE OF AUTOMATION

3.1 Control Philosophy

The control system will start up, shut down, and control plant operation within limits and will protect equipment. Combustion turbines will be provided with their own control system that will be interfaced with the plant control system.

Critical protective trips may be hardwired or routed through data highway (datalink) to allow the equipment to be safely shutdown without waiting [or operator intervention. The control system will alert the operator of malfunctions in the plant systems.

3.2 Degree of Automation

The plant will be automated to the extent reasonable to optimize the number of operating personnel. Primary control will be through the plant and turbine distributed control system workstations. This will reduce the complexity and size of the main control room operator stations and panels.

3.3 Centralized Control

Most of the equipment required to support plant operation will be located in the control room.

The control room will house the plant Distributed Control System (DCS) workstations as well as the turbine workstations.

Local control panels or stations will be furnished only where operator attention is required to set up a system for operation or where the equipment requires intermittent attention during plant operation. Main control room indication and control will be duplicated only for those variables required for increased plant availability.

4.0 PLANT MONITORING AND CONTROL SYSTEM

4.1 Turbine Control

4.1.1 Equipment

The majority of plant equipment control and information functions will be implemented in the DCS. The combustion turbine control systems and steam turbine control systems will interface with the DCS through redundant datalinks and a limited complement of hard-wired 110 for operator actions and information display; however, the CTG and STG equipment control and

protection logic will be implemented in the proprietary control systems provided by the respective equipment suppliers with supervisory control (start, stop, load control) available through the DCS.

The DCS will be a microprocessor-based system composed of functionally distributed (modular) processors, input/output modules, and operator interface devices, all connected via a communications network The components have the capability to communicate with one another through the communications network (datalink).

Input/output modules will be used for interfacing with transmitters and other sensors, final control elements, motor starters, breakers, and other plant equipment located throughout the plant. Where control information is transmitted between processors via the data highway, the overall security and response times of the control loops and digital control operations will be designed for acceptability. Where remote I/O cabinets are used, they will be located in protected, ventilated (or air-conditioned) environments, or specified as appropriate for solid-state electronics, in accordance with the manufacturer's recommendations for the environment.

Visual display workstations will be provided in sufficient quantities to allow for ease of operation of the plant control systems, while simultaneously maintaining separate dedicated flat screen displays for alarming and data acquisition functions. All DCS displays and operator interface functions will be available on at least two independent workstations. All display stations are preferred to be x-windows compatible. The workstations will include keyboards for entering operator-initiated control commands. "Hard-wired" devices such as push buttons and indicators will be limited to those required by codes and regulations, and those provided for hard-wired emergency shutdown push buttons in the unlikely event of control system failure.

The DCS will include spare capacity and equipment, and provisions for future expansions.

Redundant and secure power supplies will be provided for all control components in the system.

The DCS will be equipped with the manufacturer's standard diagnostic package. The occurrence of any malfunction or equipment failure will be alarmed.

The DCS will be designed to react in a predictable manner to certain failure:

- Upon system logic power supply failure, the controller will transfer to its backup. If the backup is unavailable, the system outputs will fail to a de-energized state.

- Upon power failure to an active or running controlled device or equipment, the system will react in a predetermined manner, i.e. cycling the logic to a status requiring equipment shutdown.

The response time of the system will be sufficient to maintain control over the plant processes under all system operating conditions including extreme plant upset conditions with all points in alarm. The response time is the total elapsed time for transmission of data through the system communication path. This time will include all communication time from processor to processor, 110 scans, nodes, gateways, CRTs, keyboards, and associated equipment internal to the system.

4.1.2 Equipment Function

The DCS will provide modulating control, digital control, monitoring, alarming, logging, data archiving, and indicating functions for the plant systems. The following functions will be provided:

- Overall Control of heat recovery steam generator (HRSG), with interface to the steam turbine and combustion turbine control system, and other systems in a coordinated response to unit load demands.
- Control of the balance-of-plant process equipment, including the steam, feedwater condensate cycle, auxiliary cooling water, water quality control systems, cycle chemical feed system, and other process systems.
- Operator interface for the turbine generator controls for manual or automatic load control.
- Operator interface for the auxiliary electric system.
- Visual alarms for abnormal events based on field signals or software generated signals from the systems, processes, or equipment.
- Provide operator interface through control consoles consisting of CRTs, keyboards, trackballs, and printers.
- On-line hardware and software diagnostics with tuning capability.
- Monitor plant equipment and process parameters and provide this information to the plant operators in a meaningful format.

4.2 Generator Control Panel

Each generator will be controlled and protected by the manufacturer's standard protection and control system. This may include a combination of a control panel and software incorporated in the turbine control system.

4.2.1 Equipment

The standard generator control panel may include the following control equipment, meters, switches, functions, and relays:

- Voltage control switch (controls voltage when off line and reactive power when on line)
- Ammeter with selector switch for generator phase current
- Wattmeter
- Varmeter

- Watt-hour meters for generator output and auxiliary power
- Generator coolant (hydrogen) and stator temperature meter (with selector switch)
- Synchronizing selector switch, "Auto-Manual"
- Voltmeter, generator field
- Ammeter, generator field
- Generator protective relays
- Generator synchronizing equipment, including (may be integrated in turbine control system):

  - Synchroscope (for indication of phase relationship between generator and bus)
  - Frequency meter
  - Bus voltmeter with selector switch
  - Incoming voltmeter (to indicate generator voltage)
  - Synchronizing lamps to indicate phase relationship between generator and bus
  - Light and outlets.

5.0 STANDARD INSTRUMENTATION REQUIREMENTS

5.1 Signal and Power Levels

Pneumatic signals levels, where used, will be standard industry ranges for pneumatic transmitter outputs, controller outputs, electric-to-pneumatic converter outputs, valve positioner inputs, etc.

In general, analog electronic transmitter output signals will be 4 to 20 mA dc. Other than for thermocouples, no primary sensor full-scale signal level will be less than 10 mV or greater than 125V.

Field contacts in process sensing switches will have minimum ratings of 5 A at 120 VAC and 0.5 A at 125 VDC.

5.2 Pressure Instruments

Pressure gauges on process piping will be visible from an operator's normal stance at floor or platform level and will be resistant to plant atmospheres. Standard industrial-type gauges will be used.

Pressure gauge accuracy will be ±0.5 percent of full range in accordance with ANSI B40.1, Grade 2A.

Pulsation effects in pulsating services will be mitigated by the pressure device or its accessories.

In general, pressure instruments will have linear scales with units in psig.

Fire protection system pressure gauges will be designed in accordance with Underwriters' Laboratories (UL) standards.

Pressure test points will have isolation valves and caps.

5.3 Flow Instruments

Flow elements such as vortex-shedding meters, annubars, flow nozzles, coriolis, magnetic flow meters, or orifice plates will be used to measure flow, as dictated by the process and accuracy requirements.

Flow transmitters will typically be the differential pressure type, with the range matching (as closely as practical) the primary element.

In general, flow instruments will have linear scales with flow units as follows:

- Liquids - gpm or lb/hr
- Gases - scfm or scfh

5.4 Level Instruments

Gauge glasses used in conjunction will level instruments will cover a range equal to or in excess of that covered by the instrument.

Reflex- or magnetic-type gauge glasses will be used. Level indication for corrosive service (if required) will use devices other than reflex-glass gauges.

Level transmitters for measuring the level in storage tanks vented to atmosphere will generally be the differential pressure type and will have local as well as control room indication.

5.5 Temperature Instruments

Temperature elements and dial thermometers will be protected by thermowells except when measuring gas or air temperatures at atmospheric pressure. Temperature test points will have thermowells and caps or plugs.

Dial thermometers will generally be visible from an operator's normal stance at floor or platform level (viewing area) and will be resistant to plant atmospheres.

If a thermocouple is inaccessible, the leads will be brought to an accessible junction box.

Thermocouples (if used) will be dual-element, ungrounded, isolated, spring-loaded, chromel alumel (ISA Type K) for general service.

Thermocouple heads will be the cast type.

In general, temperature instruments will have scales with temperature units in degrees Fahrenheit. Exceptions to this are electrical machinery resistance temperature detectors (RTD5) and transformer winding temperatures, which are in degrees Celsius.

RTDs will be 100 ohm platinum, three-wire circuits, and ungrounded. The element will be spring loaded, mounted in a thermowell, and connected to a cast iron head assembly.

5.6 Pressure and Temperature Switches

Field-mounted pressure and temperature switches will be provided in either NEMA Type 4 housings or housings suitable for the environment.

In general, switches will be applied so that the actuation point is within the center one-third of the instrument range.

5.7 Control Valves

Control valves in throttling service will have body materials, pressure rating, and valve trims suitable for the service involved. Other style valve bodies (e.g., ball, butterfly, eccentric disk) may also be used when suitable for the intended service.

Control valve actuators will be the pneumatic-spring diaphragm or piston type. The actuators will be sized to shut off against at least 110 percent of the maximum shutoff pressure.

Actuators will be designed to function with instrument air pressure ranging from 60 to 125 psig.

Valves will be designed to fail in a safe position.

In general, control valves will be specified for a noise level no greater than 90 DBA when measured 3 feet downstream and 3 feet away from the pipe surface.

Control valve accessories, excluding controllers, will be mounted on the valve actuator unless severe vibration is expected.

Valve position switches (with input to the control system for display) will be provided only for critical valve position (e.g., confirmation of whether valve is closed or not closed).

6.0 FIELD INSTRUMENT APPLICATION AND INSTALLATION

6.1 Field-Mounted Instruments

Where practical, field mounted instruments will be grouped. They will be mounted in areas that are accessible for maintenance, free of vibration, and not blocking walkways or preventing maintenance of other equipment.

Field-mounted instruments will be of a design suitable for the area in which they are located. Freeze protection will be provided as required.

Individual field instrument sensing lines will be run in horizontal (slope 1/4-inch per foot) and vertical lengths that do not affect signal response. Sensing lines will typically be run within 20 feet of the process connection.

Differential pressure instruments will be fitted with three-valve manifolds. Where specified, test tees, as required for instrument testing will be provided.

6.2 Local Instrument and Control Applications

6.2.1 Local Pneumatic Control Loops

During plant startup, shutdown, and normal operations, operator action will be required at a number of local equipment and control devices. In general, auxiliary equipment, valves, and other devices that can be properly commissioned or positioned at least 30 minutes before being required for plant functions will be furnished for local operation and control. Local pneumatic controls and remote status monitoring will be provided where remote operator adjustment is not required or recommended.

In general, local control loops will use a locally mounted indicating controller (pressure, temperature) flow, etc.).

In general, liquid level controllers will be the nonindicating displacement type with external cages.

6.2.2 Pump Controls

Critical pumps needed to function during plant startup, normal operation, and shutdown will be controlled from the control room. Pumps included with miscellaneous mechanical systems having self-contained local controls will not be controlled from the control room.

Pumps will have at least suction and discharge pressure test points.

APPENDIX C.5

Electrical

APPENDIX C.5

ELECTRICAL ENGINEERING DESIGN CRITERIA

1.0 INTRODUCTION

Project design, engineering, procurement, and construction activities will be controlled in accordance with various predetermined standard practices. An orderly sequence of events for project implementation is planned, consisting of the following major activities:

- Conceptual design
- Licensing and permitting
- Detailed design
- Procurement
- Construction and construction management
- Checkout, testing, and startup
- Project completion

This appendix summarizes the codes and standards, standard design criteria, and industrial good practices that will be used during the project. The general electrical design criteria defined herein form the basis of the design for project electrical components and systems. More-specific design information will be developed during detailed design to support equipment and erection specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize this information.

Section 2 summarizes the applicable codes and standards, and Section 3 includes the general design criteria for motors, power and control wiring, protective relaying, classification of hazardous areas, grounding, lighting, heat tracing, lightning protection, raceway and conduit, 230 kV transmission lines, and cathodic protection.

Manufactured equipment (i.e. turbines, compressors, heat recovery steam generators, and the like) will be purchased from quality, reputable manufacturer's that normally supply equipment for the intended application in this industry. The manufactured equipment and associated components and systems will be the manufacturer's standard supply for the application and will meet general industry accepted Codes and Standards, applicable to that equipment. Manufactured equipment will not necessarily meet all the requirements of this section.

2.0 DESIGN CODES AND STANDARDS

Work will be designed and specified in accordance with applicable laws and regulations of the Federal Government, the State of California and applicable local codes and ordinances.
The following summary of codes and standards, as applicable to power plants, will be followed for the electrical design and construction of the plant, with the exception of manufactured equipment where the equipment manufacturer's requirements will govern:

- Antifriction Bearing Manufacturers Association (AFBMA)
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)

- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- Illuminating Engineering Society (IES)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- Occupational Safety and Health Act (OSHA)
- Underwriters' Laboratories Inc. (UL)
- Electric Power Research Institute (EPRI)
- North American Electric Reliability Council (NERC)
- Western Electricity Coordinating Council (WECC)
- National Association of Corrosion Engineers
- California Electrical Code
- California Building Standards Code

Other recognized standards will be used as required to serve as design, fabrication, and construction guidelines when not in conflict with the above-listed standards.

The industry standards used for design, fabrication and construction will be the industry standards, including all addenda, in effect as stated in equipment and construction purchase or contract documents.

2.1 GENERAL SEISMIC REQUIREMENTS

When equipment is available that meets the seismic criteria for the site, it will be specified and the design will proceed based on the project-specific seismic requirements.

3.0 ELECTRICAL DESIGN CRITERIA

3.1 ELECTRIC MOTORS

3.1.1 Design Criteria

Motors will be designed, manufactured, and tested in accordance with the latest applicable standards, codes and technical definitions of ANSI, IEEE and NEMA and AFI3MA stated in this appendix. Motors will be totally enclosed unless specified otherwise.
Design and construction of each motor will be coordinated with the driven equipment requirements and the requirements of NEMA MG1 standards. Motors for service in hazardous areas will be individually considered as to type of enclosure, depending on the classification, group, and division of the hazardous area in question.

3.1.1.1 Electrical Design Criteria

Special requirements for individual motors and specifications for special application motors will be included in individual specification technical sections. The motor nameplate horsepower multiplied by the motor nameplate service factor will be at least 15 percent greater than the driven equipment operating maximum brake horsepower. For motors with 1.15 service factor, the maximum load brake horsepower will not exceed the motor nameplate horsepower.

Emergency dc motors will operate continuously at the nominal system voltage with any supply voltage between 85 and 110 percent of the nominal 125 VDC system voltage.

Alternating current motors will be designed for full-voltage starting and frequent starting, where required, and will be suitable for continuous duty in the specified ambient conditions.

Intermittent-duty motors will be selected where recognized and defined as standard by the equipment standards and codes.

The torque characteristics of induction motors will be as required to accelerate the inertia loads of the motor and driven equipment to full speed without damage to the motor or the equipment at any voltage from 90 to 110 percent of motor nameplate voltage, except those to be individually specified.

- **Temperature Considerations**

Integral horsepower motors will be designed for an ambient temperature of 40°C unless site conditions require higher.

- **Windings and Insulation**

Insulated windings will have Class F nonhygroscopic insulation systems with Class B temperature rise and ambient temperature in accordance with NEMA MG1 standards.

Insulated stator winding conductors and wound-rotor motor secondary windings will be copper. The insulation resistance corrected to 400 C will be not less than motor rated kV + 1 megohms for all windings. Where required, the windings will be treated with a resilient, abrasion-resistant material.

Overspeed squirrel-cage and wound-rotor induction motors, except crane motors, will be so constructed that in an emergency of short duration they will withstand, without mechanical injury, overspeeds above synchronous speed in accordance with the table in NEMA MG1- 1148, Overspeeds for Motors.

- **Space Heaters**

Space heaters will be sized as required to maintain the motor internal temperature above the dew point when the motor is not running. Motor space heaters will not cause winding temperatures to exceed rated limiting values or cause thermal protective device over-temperature indication when the motor is not energized.

All 4000 V motors will have space heaters. Heaters will be located and insulated so that they do not damage motor components or finish. Space heater leads will be stranded copper cable with 600 V insulation and will include terminal connectors.

- **Nameplates**
  Motor nameplate data will conform to NEMA MG 1-20.60 requirements. The following additional nameplate data will be included for 4000 V rated motors:

Manufacturer's identification number.

Frame size number.

Insulation system class designation.

Maximum ambient temperature for which the motor is designed or the temperature rise by resistance.

Service factor.

Starting limitations.

Direction of rotation and voltage sequence.

AFBMA bearing identification number for motors furnished with rolling element bearings.

For motors designed for service in hazardous areas will have the following additional data:

Location class and group designation.

Maximum operating temperature value or operating temperature code number.

- **Environment**

Location of individual motors within the plant will determine ambient temperature, corrosive environment, hazardous environment, and humidity to be experienced by the motors. These conditions will be considered in the purchase specification.

3.1.1.2 Safety Considerations for Motors

The Occupational Safety and Health Administration rules will be followed for personnel protection. Belt guards will be specified for personnel safety and, when required, to prevent foreign objects from contacting belt surfaces. Guard screens will be provided over motor enclosure openings to prevent direct access to rotating parts. Electrical motors will be adequately grounded.

Motors in hazardous areas will conform to applicable regulatory requirements and will be UL labeled. Motor electrical connections will be terminated within oversized conduit boxes mounted to the motor frame.

3.1.1.3 Testing Requirements

Each type of ac and dc machine will be tested in accordance with the national Codes stated in section 2 and the manufacturer's routine tests at the factory to determine that it is free from electrical or mechanical defects and to provide assurance that it meets specified requirements.

3.1.2 4000 Volt Squirrel-Cage Induction Motors

3.1.2.1 Design and Construction

Design and construction of 4000 V motors will be coordinated with the driven equipment requirements.

Motor power lead terminal housings will be adequately sized to terminate the power conductors. For 4000 V motors, the power lead terminal housing will also be large enough to provide working space for field fabrication of stress cones within the housing and to contain the stress cones after installation.

Separate terminal housings will be provided for power leads, accessory leads and temperature detector leads.

Leads will be wired into their respective terminal housings. Motor leads and their terminals will be permanently marked in accordance with the requirements of NEMA MG1, Part 2. Each lead marking will be visible after the terminals are taped. Motor power lead terminal housing will be sized to allow for ease in terminating the incoming power cable. Space heater leads will also be routed into this terminal housing.

Motors designed to rotate in only one direction will have the direction of rotation marked by an arrow mounted visibly on the stator frame near the terminal housings or on the nameplate and the leads marked for phase sequence T1, T2, T3 to correspond to the direction of rotation and supply voltage sequence.

Outdoor motors will be NEMA WPI or WPII. Indoor motors in wet areas will have outdoor motor features.

3.1.2.2 Insulation

All motors shall be furnished with Class F insulation systems, provided the temperature rise is based on Class B maximum. An insulation resistance time curve corrected to 40°C for determining the polarization index for motor stator windings will be taken immediately before making the final high potential ground test. Bach stator phase will be tested separately to ground, with other phases grounded. Motors will be tested at not less than 5000 VDC. The ambient temperature, winding temperature, and relative humidity values will be included with the recorded data. The polarization index will not be less than 3 0. An insulation-to-ground dielectric test will be made on the motor windings at a value of two times rated voltage + 1,000.

3.1.2.3 Bearings

Horizontal motors, except motors for belted drives, will have split sleeve bearings of oil ring type, unless required otherwise. Sleeve bearings on horizontal motors will be designed and located centrally with respect to running magnetic center to prevent the rotor axial thrust from being continuously applied against either end of the bearing. The motors will be able to withstand without damage the axial thrusts developed when the motor is energized.

When sleeve bearings are not specified, horizontal motors will have antifriction bearings.

Thrust bearings for vertical motors will be able to operate for extended periods of time at any of the thrust loadings imposed by the specific piece of driven equipment during starting and normal operation, without damage to the bearings, the motor frame, or other motor parts.

Motors with spherical roller thrust bearings will also have ball or roller guide bearings. Bearing lubricants will contain a corrosion inhibitor. The type and grade of lubricant will be indicated on a nameplate attachment to the motor frame or end shield adjacent to the lubricant filling device. Insulation will be provided on bearing temperature detectors and on oil piping connections when required to prevent circulation of shaft current through bearings. Bearings and bearing housings will be designed to permit disassembly in the field for bearing inspection or rotor removal.

3.1.2.4 Bearing Temperature Detectors

Thermocouple bearing temperature detectors complete with detector head and holder assemblies as required, will be furnished. Thermocouple lead wire insulation will be color coded with standard colors to represent the thermocouple metals.

3.1.2.5 Winding Temperature Detectors

Winding temperature detectors will be furnished, installed, and wired complete. Temperature detectors will normally be three-wire resistance platinum temperature detectors (RTDs).

3.1.2.6 Temperature Detector and Terminal Block Requirements

Temperature detectors will be ungrounded, with detector leads wired to terminal blocks furnished in the accessory terminal housings. A grounding terminal for each temperature detector will be included with the detector lead terminals. The grounding terminals will be wired internally to a common ground connection in each terminal box. The internal wiring will be removable.

3.2 POWER AND CONTROL WIRING

3.2.1 Design Conditions

In general, conductors will be insulated on the basis of a normal maximum conductor temperature of 90° C in 40° C ambient air, with a maximum emergency overload temperature of 130° C and a short-circuit temperature of 250° C. In areas with higher ambient temperatures, larger conductors will be used or higher temperature rated insulation will be selected. Conductor size and ampacity will be coordinated with circuit protective devices. Cable feeders from 4.16 kV switchgear to power equipment will be sized so that a short- circuit fault at the terminals of the load will not result in damage to the cable before normal operation of fault interrupting device (breaker is tripped or fuse is melted).

- Instrument cable will be shielded and twisted to minimize electrical noise interference as follows:

- Aluminum-polyester tape with 100 percent coverage and copper drain wire will be used for shielding.

- Low-level analog signal cables will be made up of twisted and shielded pairs.

- Except where specific reasons dictate otherwise, cable shields will be electrically continuous. When two lengths of shielded cable are connected together at a terminal block, a point on the terminal block will be used for connecting the shields.

- For multi-pair cables using individual pair shields, the shields will be isolated from each other.

3.2.2 Conductors

Electrical conductors will be selected with an insulation level applicable to the system voltage for which they are used and ampacities suitable for the load being served. The type of cable used will be determined by individual circuit requirements and individual equipment manufacturer's recommendations.

The maximum ampacities for any cable will be in accordance with the NEC. In addition to ampacity, special requirements such as voltage drop, fault current availability, and environment will be taken into consideration when sizing cable.

3.2.3 Insulation and Construction

Cable insulation and construction will be as follows.

- **Flame Retardance**
  To minimize the damage that can be caused by a cable fire, cables will have insulations and jackets with nonpropagating and self-extinguishing characteristics. As a minimum, these cables will meet the flame test requirements of IEEE *383,* using a gas-burner flame source, These characteristics are essential for cables installed in electrical cable tray in the plant.

- **Medium Voltage Power Cable**
  Power cable with minimum *5* kV class insulation will supply all 4.16 kV service and will be routed in trays, conduits, or underground duct banks.

- **Low Voltage Power Cable, 600 Volts**
  Power cable with 600 V class insulation will supply power to loads at voltage levels of 480 VAC and below and 125 VDC and below. Cables will be routed in trays, conduits, or ducts.

- **Control Cable. 600 Volts**
  Nonshielded control cable with 600 V class insulation will be used for control, metering, and relaying. Cables will be routed in trays, conduits, or ducts.

- **Instrument Cable. 300 or 600 Volts**
  Instrument cable will be used for control and instrument circuits that require shielding to avoid induced currents and voltages.

- **Thermocouple Extension Cable**
  Thermocouple extension cable will be used for extension leads from thermocouples to junction boxes and to instruments for temperature measurements. Cables will be routed in trays or conduits.

- **High Temperature Cable**
  High temperature cable will be used for wiring to devices located in areas with ambient temperatures normally above 75° C. Cables will be routed in conduit. Cable lengths will be minimized by terminating the cable at terminal boxes or conduit outlet fittings located outside the high temperature area and continuing the circuit with control or thermocouple extension cable.

- **Lighting and Fixture Cable**
  Lighting and fixture cable designations and conductor sizes will be identified on the drawings. The wire used for interior lighting and receptacles will be copper 600 V. 75 degree Type THWN insulation or equal.

- **Grounding Cable**
  Grounding cable will be insulated or uninsulated bare copper conductor sized as required.

- **Switchboard and Panel Cable**
  Switchboard and panel cable will be insulated to 600 V. Cable will be NEC Type SIS or XHHW-2, meeting the UL VW-I flame test.

- **Special Cable**
  Special cable will include cable supplied with equipment, prefabricated cable, coaxial cable, communication cable, etc. This cable will normally be supplied by a particular manufacturer. Special cable will be routed in accordance with the manufacturer's recommendations.

- **Miscellaneous Cable**
  If other types and constructions of cable are required as design and construction of the unit progress, they will be designated and routed as required.

3.2.4 Testing Requirements

Pre-operational tests will be performed on insulated conductors after installation, as follows:

- Insulated conductors with insulation rated 5000 V and above will be given a field dc insulation test as specified in Part 6 of ICEA Standards S-68-516 and 5- 66-524.

- Low-voltage cables will be either insulation-resistance tested before connecting to equipment or functionally tested (at equipment operation voltage) as part of the checkout of the equipment system.

- Insulated conductors will be continuity-tested for correct conductor identification.

3.2.5 Installation

- Cable installation will be in accordance with the following general rules:
- Cables will be routed as indicated in the circuit raceway schedule.
- Cable pulling tension will not exceed the maximum tension recommended by the cable manufacturer, and the pulling tension in pounds at a bend will not exceed the cable manufacturer's recommendations for sidewall pressure. Minimum bend radii will not exceed the manufacturer's recommendations.
- Cable will be exercised to prevent tension and bending conditions in violation of the manufacturer's recommendations.
- Cable supports and securing devices will have bearing surfaces located parallel to the surfaces of the cable sheath and will be installed to provide adequate support without cutting or deforming the cable jackets or insulation.
- Nylon ties will be used to lace together conductors entering panelboards, control panels, and similar locations after the conductors have emerged from their supporting raceway and before they are attached to terminals.
- Both ends of circuits will be identified.
- Spare conductors of a multiconductor cable will be left at their maximum length for possible replacement of any other conductor in the cable.
- Cables will be installed in accordance with manufacturer's requirements and recommendations.

3.2.6 Connectors

This subsection defines methods of connecting cable between electrical systems and equipment. In this subsection, the term "connector" is applied to devices that join two or more conductors or are used to terminate conductors at equipment terminals to provide a continuous electrical path.

Medium voltage cables will have stress cones at their terminations if shielded cables are used. Stress cones will be the preformed types suitable for the cable to which they are to be applied.

Power cables will be designed not spliced. Control and low-level instrument cable will be spliced only at pigtails and at the transition to high temperature wire. Connections will be made in conduit fittings or junction boxes, using terminal blocks or an appropriate connector.

3.3 PROTECTIVE RELAYING

The selection and application of protective relays are discussed in the following paragraphs. These relays protect equipment in the electrical transmission, generation, and distribution systems.

3.3.1 General Requirements

The following general requirements apply to all protective relay applications:

The protective relaying scheme will be designed to remove or alarm any of the following abnormal occurrences:

- Overcurrent
- Undervoltage or over-voltage
- Frequency variations
- Over-temperature
- Abnormal pressure
- Open circuits and unbalanced current
- Abnormal direction of power flow

The protective relaying system will be a coordinated application of microprocessor based multifunction relays. For each monitored abnormal condition, there will exist a designated primary device to detect that condition. If possible, secondary relaying will be provided with an overlapping scheme to detect the effect of the same abnormal occurrence. Alternate relays may exist to detect the initial abnormal condition but with an inherent time delay so that the alternate relays will operate after the primary and secondary relays. Similarly to secondary relays, the alternate relays may be primary relays for other abnormal conditions. Protective relays will be selected to coordinate with protective devices supplied by manufacturers of major items and the thermal limits of electrical equipment, such as transformers and motors.

Secondary current produced by current transformers will be in the *0-5* A range, and voltage signals produced by voltage transformers will normally be 120 V.

3.3.2 Generator Protective Relays

Protective relay packages will be manufactures standard and include the following functions:

- Generator phase faults
- Generator stator ground faults
- Stator open circuits and unbalanced currents (negative sequence) '
- Loss of excitation
- Backup protection for external system faults
- Reverse power
- Generator voltage transformer circuit monitoring
- Under-frequency/over-frequency
- Synch-check
- Breaker failure

Equipment furnished with the generator's excitation equipment will provide the following additional protection:

- Underexcitation
- Overexcitation
- Generator field ground faults

- Excessive volts per hertz

Additional generator protective monitoring equipment will be provided to protect against the following:

- High bearing temperatures
- Overspeed conditions
- Excessive vibrations
- Generator overheating
- Loss of generator coolant
- High generator coolant temperature

A typical complement of protective relays for the turbine generator may be as follows. The actual protective relaying to be used will be similar and will be developed during design stages:

- Generator Differential Relay
- Generator Ground Relay
- Negative Sequence Relay
- Loss-of-Field Relay
- Reverse Power Relay.
- Voltage Balance Relay.
- Underfrequency Relay
- Overvoltage Relay
- Field Ground Fault Protection Relay
- Generator Backup Distance Relay
- Synch-Check

3.3.3 Power Transformer Relays

3.3.3.1 Generator Transformer

The generator step-up transformer will be protected against the effects of the following conditions:

- Phase faults
- Ground faults
- Sudden pressure
- Overheating

This protection will be provided by the following relays:

- Differential Relay
- Time Overcurrent Relay
- Sudden-Pressure Relay.
- Overtemperature

3.3.3.2 Unit Auxiliary Transformers.

The unit auxiliary transformers will be protected against the effects of the following conditions:

- Phase faults
- Ground faults
- Sudden pressure
- Overheating

This protection will be provided by the following relays:

- Differential Relay
- Time Overcurrent Relay
- Sudden-Pressure Relay
- Overtemperature

3.3.4 Metal-Clad Switchgear

The protective relays used in the 4,160 V metal-clad switchgear lineups are discussed in the following paragraphs.

3.3.4.1 Incoming Breakers

Each incoming breaker will have time overcurrent relays and a time overcurrent ground detection relay. This will detect and trip the respective switchgear incoming breaker for sustained overloads and short-circuit currents on the switchgear bus. These relays will provide backup protection for faults on feeders emanating from the switchgear lineups. Device 51N will be residually connected to switchgear current transformers and provide primary protection for ground faults on the switchgear bus and backup protection for ground faults in feeders emanating from the switchgear lineup.

The medium voltage switchgear bus will have undervoltage relays or transducers to detect bus voltage drops to a preset level.

3.3.4.2 Low Voltage Load Center

Each load center transformer will be protected by a 4.16 kV fused latched contactor or circuit breaker. Protection devices will include time over-current relays instantaneous current relays, and ground fault relays or a multifunction transformer protection relay.

3.3.4.3 Medium Voltage Motor Feeders

Each single-speed induction motor will be protected by main line fuses and a microprocessor motor protection/management relay (MPR) The MPR will provide primary equipment and cable time overcurrent, instantaneous overcurrent, open phase, and zero sequence protection.

3.3.5 480 Volt Load Center Switchgear

Overload and fault protection for loads connected to the 480 V load center switchgear will be provided by solid-state trip devices (SSTDs), which are an integral part of the circuit breakers.

Breakers supplying motors or other devices that do not require coordination with downstream trip devices will have adjustable long-time and instantaneous elements for phase protection and will include ground fault protection.

Main breakers, tie breakers (if any), and breakers supplying motor control centers (MCCs) or other loads that contain trip devices will have adjustable long-time and short-time SSTD elements for phase protection and will include ground fault protection. The pickup point and time settings will be adjustable to allow for proper coordination with all downstream trip devices.

Sustained undervoltage in the 480 V load center switchgear bus will be detected by undervoltage relays transducers.

3.3.5.1 480-Volt Motor Control Centers

MCCs will be protected by the 480 V switchgear feeder breakers or an incoming main circuit breaker, which have adjustable long-time and short time SSTD elements for phase protection and ground fault protection in a manner similar to that for 480-Volt Load Center Switchgear. The SSTD will protect the MCC feeder circuit and the bus against sustained short-circuit currents and serve as backup protection for MCC feeder circuits.

Each magnetic starter within an MCC that supplies power to a motor will have an adjustable motor circuit protector, or thermal-magnetic circuit breaker and a thermal overload element in the starter.

Certain non-motor loads will be fed from MCC feeder circuit breakers. The feeder breakers will be thermal-magnetic molded-case breakers sized to protect supply cable and individual loads.

3.3.5.2 480-Volt Power Panels

Power panels will have thermal-magnetic circuit breakers sized to protect supply cable and individual loads.

3.4 CLASS IFICATION OF HAZARDOUS AREA

Areas where flammable and combustible liquids, gases, and dusts are handled and stored will be classified for the purpose of determining the minimum criteria for design and installation of electrical equipment to minimize the possibility of ignition. The criteria for determining the appropriate classification are specified in NEC Article 500 (NFPA 70/ANSI C1). Electrical equipment in areas classified as hazardous will be constructed and installed in accordance with NEC Articles 501 and 502.

3.5 GROUNDING

The station grounding system will be in an interconnected network of bare copper conductor and copper-clad ground rods. The system will protect plant personnel and equipment from the hazards that can occur during power system faults and lightning strikes.

3.5.1 Design Basis

The station grounding grid will be designed for adequate capacity to dissipate energy from ground fault current under the most severe conditions, with grid spacing such that safe voltage gradients are maintained. The system will be in accordance with IEEE 80, IEEE 142, and NEC, NFPA 70.

Bare conductors installed below grade will be spaced in a grid pattern to be indicated on the construction drawings. Each junction of the grid below grade will be bonded together.

Ground stingers will be brought through the ground floor and connected to the building steel and selected equipment. Also, the grounding system will be extended, by way of stingers and conductor installed in cable tray, to the remaining plant equipment.

Equipment grounds will conform to the following general guidelines:

- Grounds will conform to NEC.
- Major equipment, such as switchgear, MCCs, relay panels, and control panels, will have integral ground buses that will be connected to the station ground grid.
- Electronic panels and equipment, where required, will be grounded using an insulated ground wire connected in accordance with the manufacturer's recommendations.
- Motor supply circuits to 460 V motors, which use four-conductor cable or three-conductor cable with a wound in the interstices, will use this ground for the motor ground. For 460 V motor supply circuits, which use three single- conductor cables, a separate ground conductor will be used.
- All 4000 V motors will have a minimum of one 1/0 AWG bare copper ground conductor connected between the motor frame and the station wound grid.
- Single-conductor ground wires installed in conduit will be insulated.

3.5.2 Materials

Ground rods will be copper. Rod length and diameter will be determined by soil resistivity and subsurface mechanical properties. Where the required ground rod length exceeds 10 feet, standard sections will be connected together.

Cable will be either soft-drawn copper with Class B stranding or copper-clad steel.

Compression-type or thermo-weld connectors that meet the requirements of IEEE 837 will be used for the buried connectors.

Clamps, connectors, and other hardware used with the grounding system will be designed for that use and purchased from an approved supplier.

Ground wires installed in conduit will be soft-drawn copper with Class B stranding and green-colored 600 V insulation. Ground wires larger than No. 6 AWG may be marked green in lieu of green-colored insulation.

3.6 SITE LIGHTING

The site lighting system will provide personnel with illumination to perform general yard task, safety, and plant security. Power used to supply outdoor roadway and area lighting fixtures will be at 480 or 208 V.

3.6.1 Light Sources

The lighting system will be designed to provide illumination levels recommended by the following standards and organizations:

- IES RP-7 - Standard Practice for Industrial Lighting
- IES RP-8 - Standard Practice for Roadway Lighting
- IES RP-24 - Standard Practice for Lighting Offices Containing Computer Display Terminals

Light source size and fixture selections will be based on the applicability of the luminaries for the area under consideration during detail design.

3.6.2 Roadway and Area

Roadway and area lighting will be designed using high-pressure sodium light sources. The light fixtures will be the cutoff types designed to control and direct light within the property line of the facilities. Roadway light fixtures will be installed on hot-dip galvanized steel poles. Local task lighting will be installed on buildings or equipment.

3.6.3 Lighting Control

Electric power to outdoor light fixtures will be switched on and off with photoelectric controllers. Local task lighting will be controlled with manual switches at the task.

3.7 FREEZE PROTECTION

Freeze protection will be provided for small diameter lines subject to freezing during normal operation, or where it is impractical to drain the lines or equipment during an extended shutdown.

3.7.1 Lightning Protection

Lightning protection will be provided, as required, for all structures.

Lightning protection will be provided for buildings and structures generally in accordance with NFPA 780 but will not be UL "Master" labeled.

3.8 RACEWAY AND CONDUIT

The design and specifications for the raceway and conduit systems used to support and protect electrical cable will be in accordance with NEC provisions.

3.8.1 Cable Tray

Cable trays will be the trough or ladder types with a maximum rung spacing of 9 in., nominal depths of 4 to 6 in, and various widths as required. Horizontal trays will have a maximum spacing of 20 ft between cable tray supports; vertical trays. 8 ft.

Fittings (elbows, tees, etc.) will be supported in accordance with NEMA standards and will have a radius equal to or greater than the minimum bending radius of the cables they contain.

Electric systems such as special noise sensitive circuits and analog instrumentation circuits will have solid bottom trays.

For 4.16 kV power cables, the summation of the cross-sectional areas of cable in tray will be limited to 30 percent of the usable cross section of the tray. For 480 V power and control cables, the limit will be 40 percent. For instrument cable, the limit will be 50 percent.

The minimum design vertical spacing for trays will be 12 in., measured from the bottom of the upper tray to the top of the lower tray. At least a 9-in, clearance will be maintained between the top of a tray and beams, piping, or other obstacles to facilitate installation of cables in the tray. A working space of not less than 24 in. will be maintained on at least one side of each tray.

Vertical trays will have covers that allow ventilation. Solid bottom tray and outdoor tray will have solid covers. The top tray of horizontal tray runs located under floor grating will also have solid covers. All outside cable tray will be covered.

3.8.2 Conduit

Conduit will be used to protect conductors routed to individual devices, in hazardous areas, and where the quantity of cable does not economically justify the use of cable tray.

Electrical metallic tubing (EMT) will be used indoors in non-hazardous areas for lighting branch circuits and communication circuits.

PVC, EMT, and rigid galvanized steel conduit will be used for underground duct banks and some below grade, concrete-encased conduit.

Liquid tight, flexible metallic conduit will be used for connections to accessory devices such as solenoid valves, limit switches, pressure switches, etc.; for connections to motors or other vibrating equipment; and across areas where expansion or movement of the conduit is required.

Exposed conduit, unless specific environmental requirements dictate the use of plastic or aluminum conduit, will be rigid galvanized steel.

Exposed conduit will be routed parallel or perpendicular to dominant surfaces.

Conduit in finished areas, such as the offices and control room, will normally be concealed. Conduit will be routed at least 6 in. from the insulated surfaces of hot water, steam pipes, and other hot surfaces. Where conduit must be routed parallel to hot surfaces, high-temperature cable will be used.

Conduit will be sized in accordance with NBC requirements. Conduit will be securely supported within 3 ft of connections to boxes and cabinet.

3.8.3 Duct Rank and Manholes

Underground circuits will be installed in reinforced duct bank, unreinforced duct bank, or in direct buried conduit, as required by the final design.

Underground conduits will be rigid Schedule 40 PVC. EMT or rigid galvanized steel conduit. Stub-ups will be made using rigid galvanized steel conduit elbows and galvanized fittings as required.

Conduit runs installed below grade (except in floor slabs) will be encased in a minimum of 3 in. of red-colored concrete on all sides. The minimum spacing between conduits in underground duct banks will be 1 -1/2 in. Reinforced concrete will be used in heavy traffic areas.

Horizontal bends in underground conduits will be made using long radius sweeps.

Duct banks will slope downward toward manholes.

As a minimum, 20 percent (or not less than one) spare conduits (2 in, minimum size) will be installed in underground duct banks, except for single- or double-conduit duct banks for street lighting or to individual remotely located equipment.

Reinforced concrete manholes and electrical vaults will be provided, where required, so that cable may be installed without exceeding allowable pulling tensions and cable sidewall pressures. Each manhole will have the following provisions:

- Provisions for attaching cable pulling devices
- Provisions for racking cables
- Manhole covers of sufficient size to loop-feed the largest diameter cable through the manhole without splicing

Conduit from manholes to the equipment at remote locations will be changed to rigid steel before emerging from below grade.

Duct bank and manholes will be designed in accordance with the seismic criteria defined in the Structural Design Criteria.

3.9 CATHODIC PROTECTION SYSTEM

Buried carbon steel natural gas pipes will be provided with cathodic protection because of the potential hazard should a leak develop. If the site's soil resistivity is less than 200 ohmmeter, then cathodic protection will be provided for all other buried coated carbon steel pipes. The cathodic protection system for buried pipes will be either impressed current or sacrificial galvanic anode, depending on soil conditions and pipe size.