# APPENDIX C
# MECHANICAL ENGINEERING DESIGN CRITERIA

## TABLE OF CONTENTS

**Page**

1.0 INTRODUCTION ..... C-1

2.0 DESIGN CODES, STANDARDS, LAWS AND ORDINANCES ..... C-1

3.0 MECHANICAL ENGINEERING GENERAL DESIGN CRITERIA ..... C-5
3.1 PIPING ..... C-5
3.1.1 Design Temperature and Pressure ..... C-5
3.1.2 General Design and Selection Criteria ..... C-6
3.1.3 Piping Materials ..... C-7
3.1.4 Tubing Materials ..... C-8
3.1.5 Fitting Materials ..... C-8
3.1.6 Flanges, Gaskets, Bolting, and Unions ..... C-8
3.1.7 Cathodic Protection ..... C-9
3.1.8 Piping Fabrication ..... C-9
3.1.9 Pipe Supports and Hangers ..... C-10
3.2 VALVES ..... C-10
3.2.1 Iron Body Valves ..... C-10
3.2.2 Butterfly Valves ..... C-10
3.2.3 Branch Line Isolation Valves ..... C-10
3.3 INSULATION AND LAGGING ..... C-10
3.3.1 Insulation Materials and Installation ..... C-11
3.3.2 Lagging Materials and Installation ..... C-11
3.3.3 Freeze Protection ..... C-11
3.4 PUMPS ..... C-11
3.5 STORAGE TANKS ..... C-12
3.6 HEAT EXCHANGERS ..... C-12
3.7 HEATING, VENTILATING AND AIR-CONDITIONING ..... C-12
3.8 HEAT RECOVERY STEAM GENERATORS (HRSGS) ..... C-13

## 1.0 INTRODUCTION

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

- Conceptual design;
- Licensing and permitting;
- Detailed design;
- Procurement;
- Construction and construction management;
- Start-up, testing, and checkout; and
- Project completion.

The purpose of this appendix is to summarize the codes and standards and standard design criteria and practices that will be used during the project. The general mechanical design criteria defined herein form the basis of the design for the mechanical components and systems of the project. More specific design information is 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 the codes, standards, and general criteria that will be used.

Section 2 summarizes the applicable codes and standards and Section 3 includes the general design criteria for piping, valves, insulation, lagging, and freeze protection.

## 2.0 DESIGN CODES, STANDARDS, LAWS AND ORDINANCES

The design and specification of all work 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. A summary of the codes and industry standards to be used in design and construction is listed below.

- AFBMA – Antifriction Bearing Manufacturers Association
- AGMA – American Gear Manufacturers Association Specification 390 – Gear Classification
- AMCA – Air Movers Control Association
- ASCE – American Society of Civil Engineers
- ASME – American Society of Mechanical Engineers Boiler and Pressure Vessel Code:
  - Section II – Materials Specification
  - Section V – Nondestructive Examination
  - PTC 22 – Performance Test Code
- ASNT – American Society for Nondestructive Testing
- AWS – American Welding Society
- AWA-D-100 Welded Steel Tanks for Water Storage
- EJMA – Expansion Joint Manufacturing Association

- EPA – Environmental Protection Agency
- HI – Hydraulic Institute
- HEI – Heat Exchange Institute
- IEEE – Institute of Electrical and Electronics Engineers
- ISA – Instrument Society of America
- NBS – National Bureau of Standards
- NEMA – National Electrical Manufacturers Association
- OSHA – Occupational Safety and Health Administration, Department of Labor
- CALOSHA – California Occupational Safety and Health Administration
- PFI – Pipe Fabrication Institute
- TEMA – Tubular Exchanger Manufacturers Association
- TIMA – Thermal Insulation Manufacturers Association
- BOCA – Building Officials and Code Administrators
- API – American Petroleum Institute
  - SL Specification for Line Pipe
- ASTM – American Society for Testing and Materials
- ASTM Standard Material Specifications
  - ASTM A36-Standard Specification for Structural Steel
  - ASTM A53-Standard Specification for Pipe, Steel Black and Hot-Dipped Zinc-Coated Welded and Seamless
  - ASTM A105-Standard Specification for Forgings, Carbon Steel for Piping Components
  - ASTM A106 Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service
  - ASTM A159 Standard Specification for EFW Steel Pipe (size 4' and over)
  - ASTM A126 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
  - ASTM A182-Standard Specification for Forged or Rolled Alloy Steel Pipe Flanges/Forged Fitting and Valves and Parts for High-Temperature Service
  - ASTM A193-Standard Specification for Alloy-Steel and Stainless Steel Bolting
- Materials for High-Temperature Service
  - ASTM A194-Standard Specifications for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
  - ASTM A213-Standard Specification for Seamless Ferritic and Austenitic Alloy Steel Boiler, Superheater, and Heat-Exchanger Tubes
  - ASTM A216-Standard Specifications for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

- ASTM A217-Standard Specification for Steel Castings, Martenistic Stainless and Alloy for Pressure Containing Parts, Suitable for High-Temperature Service
- ASTM A234-Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures
- ASTM A307-Standard Specifications for Carbon Steel Bolts and Studs, 60,000 psi, Tensile Strength
- ASTM A312-Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes
- ASTM A335-Standard Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service
- ASTM A351-Standard Specification for Steel Castings, Austenitic, for High Temperature Service
- ASTM A387-Standard Specification for Pressure Vessel Plates, Alloy Steel Chromium-Molybdenum
- ASTM A403-Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
- ASTM A490-Specification for Heat-Treated, Steel Structural Bolts, 150 ksi Tensile Strength
- ASTM B61-Standard Specification for Steam or Valve Bronze Castings
- ASTM B62-Composition Bronze or ounce Metal Castings
- ASTM B75-Standard Specification for Seamless Copper Tube
- ASTM B88-Standard Specification for Seamless Copper Water Tube
- ASTM B111-Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
- ASTM B209-Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
- ASTM C195 (83)-Specification for Mineral Fiber Thermal Insulating Cement
- ASTM L411 (87)-Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
- ASTM C533-Specification for Calcium Silicate Block and Pipe Thermal Insulation
- ASTM C612-Specification for Mineral Fiber Block and Board Thermal Insulation
- ASTM D1248-Specification for Polyethylene Plastics Molding and Extrusion Materials
- ASTM D1785-Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
- ASTM D2241-Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
- ASTM D3350-Standard Specification for Polyethylene Plastic Pipe and Fittings Materials
- ASTM F441-Specification for Chlorinated Poly (vinyl chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

- ANSI – American National Standards Institute.
  - ANSI/NFPA 70 – National Electrical Code (NEC)
  - ANSI C50.10 – Synchronous Machines
  - ANSI C50.14 – Combustion-Gas Turbine Driven Cylindrical Rotor Synchronous Generators
  - ANSI C50.22 – Guide for Testing Insulation Resistance of Rotating Machinery
  - ANSI B1.1 – Unified Inch Screw Threads (UN and UNR thread form)
  - ANSI B18.2.1 – Square and Hex Bolts and Screws, Inch Series
  - ANSI B133.1 – Procurement Standards for Gas Turbines
  - ANSI B133.8 – Gas Turbine Installation Sound Emissions

- ASME – American Society of Mechanical Engineers
  - ASME Section I – Rules for Construction of Power Boilers
  - ASME Section VIII – Rules for Construction of Pressure Vessels
  - ASME Section IX – Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators
  - ASME PTC-22 – Power Test Code for Gas Turbine Power Plants
  - ASME 1.20.1-Pipe Threads, General Purpose (inch)
  - ASME B16.1 – Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800 lb.
  - ASME B16.3 – Malleable Iron Threaded Fitting, Class 150 and 300
  - ASME B16.5 – Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys
  - ASME B16.9 – Factory-Made Wrought Steel Buttwelding Fittings
  - ASME B16.10 – Face-to-Face and End-to-End Ferrous Valves
  - ASME B16.11 – Forged Steel Fittings Socket-Welding and Threaded
  - ASME B16.20 – Metallic Gaskets for Pipe Flanges – ring Joint, Spiral Wound & Jacketed
  - ASME B16.21 – Nonmetallic Flat Gaskets for Pipe Flanges
  - ASME B16.24 – Bronze Pipe Flanges and Flanged Fittings, Class 150 and 300 lb.
  - ASME B16.25 – Buttwelding Ends
  - ASME B16.28 – Wrought Steel Buttwelding Short Radius Elbows and Returns
  - ASME B16.34 – Valves – Flanged, Threaded and Welding End
  - ASME B16.36 – Orifice Flanges
  - ASME B16.47 – Large Diameter Steel Flanges NPS26 through NPS60
  - ASME B31.1. – Power Piping
  - ASME B36.10M – Welded and Seamless Wrought Steel Pipe
  - ASME B36.19M – Stainless Steel Pipe
  - ASME B46.1 – Surface Texture
  - ANSI B73.1 – Specifications for Horizontal End Suction Centrifugal Pumps for Chemical Process

- MSS – Manufacturers Standardization Society of the Valve and Fittings Industry
  - MSS-SP 55 – Quality Standard for Steel Castings for Valves, Flanges, Fittings and Other Piping Components -Visual Method
  - MSS-SP 67 – Butterfly Valves
  - MSS-SP 80 – Bronze Gate-Globe-Angle and Check Valves
  - MSS-SP 84 – Steel Valves-Socket Welding and Threaded Ends

- AWS – American Welding Society
  - AWS – D1.1 – Structural Welding Code-Steel

- AWWA – American Water Works Association.
  - AWWA-C504 – Rubber Seated Butterfly Valves
  - AWWA-D100 – Standards for Welding Steel Tanks

- SSPC – Steel Structures Painting Council, Volume 2
  - SSPC-PA1 – Shop, Field, and Maintenance Painting
  - SSPC-PA2 – Measurement of Dry Paint Thickness with Magnetic Gages
  - SSPC-SPl – Solvent Cleaning
  - SSPC-SP2 – Hand Tool Cleaning
  - SSPC-SP3 – Power Tool Cleaning
  - SSPC-SP6 – Commercial Blast Cleaning

  - SSPC-SP8 – Pickling
  - SSPC-SP10 – Near-White Blast Cleaning

- California Administrative Code, Title 8
  - Chapters 4 through 7, Groups 20 Flammable Liquids, Gases, and Vapors
  - Group 27, Fire Protection

- National Fire Protection Association (NFPA) codes
  - NFPA 10, Portable Fire Extinguishers
  - NFPA 12, Carbon Dioxide Extinguishing Systems
  - NFPA 13, Installation of Sprinkler Systems
  - NFPA 14, Installation of Standpipe and Hose Systems
  - NFPA 15, Water Spray Fixed Systems
  - NFPA 20, Centrifugal Fire Pumps
  - NFPA 22, Fire Water Storage Tank
  - NFPA 24, Private Fire Service Mains and Their Appurtenances
  - NFPA 26, Supervision of Valves Controlling Water Supplies for Fire Protection
  - NFPA 30, Flammable and Combustible Liquids Code
  - NFPA 37, Stationary Combustion Engines and Gas Turbines.
  - NFPA 70, National Electrical Code
  - NFPA 72E, Automatic Fire Detectors
  - NFPA 214, Water cooling Towers

- California Building Code (CBC)

- International Building Code (IBC)

- UL – Underwriter Laboratory

- UFC – Uniform Fire Code

- NEC – National Electrical 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 codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including all addenda, in effect as stated in equipment and construction purchase or contract documents.

## 3.0 MECHANICAL ENGINEERING GENERAL DESIGN CRITERIA

### 3.1 PIPING

Piping will be designed, selected, and fabricated in accordance with the following criteria:

#### 3.1.1 Design Temperature and Pressure

The design pressure and temperature for piping shall be consistent with conditions established for the design of the associated system.

The design pressure of a piping system shall be the maximum of:

- The set pressure of a relief valve mounted in the line
- The set pressure of a relief valve installed on equipment that is connected to the line, adjusted accordingly to account for static head and friction loss
- If the system has no PSV or can be isolated from a PSV, the maximum pressure upstream equipment can generate (i.e., pump shutoff pressure).
- The maximum sustained pressure that may act on the system plus 25 psi.

The main and process steam piping design pressures shall be in accordance with applicable codes. All design pressure values shall be rounded up to the next 5-psig increment.

The design temperature of a piping system shall be based on:

- The maximum sustained temperature which may act on the system plus 25°F

If a heat exchanger of piece of equipment in which heat is being removed can be taken out of service or bypassed, then the line downstream of that equipment should be designed for the resulting higher temperature.

### 3.1.2 General Design and Selection Criteria

Piping will be designed in accordance with the requirements of the Code for Pressure Piping, ASME B31.1-Power Piping, and other codes and standards referenced in Section 2, Codes and Standards. Pipe stress analysis will be performed in accordance with ASME B31.1. All pipe supports will be suitable to restrain the piping where subjected to external loads as stipulated by the California Building Code – Seismic and Wind Load Criteria. Vents and drains will be provided, as service requires.

Material selection will generally be based on the design temperature and service conditions in accordance with the following:

- Carbon steel piping materials will be specified for design temperatures up to and including 800°F.

- One and one-quarter percent chromium alloy steel piping materials will be specified for design temperatures ranging from 805°F to 950°F. 2¼ percent chromium alloy steel piping may be specified for design temperatures ranging from 955°F to 1100°F, however, 9 percent chromium alloy steel piping will be specified for high pressure steam and hot reheat steam systems which have a design temperature of approximately 1065°F.

- Scale free piping materials such as cleaned carbon steel, stainless steel or non-metallic will be used as follows:

  – Piping applications requiring a high degree of cleanliness generally including injection water supply piping after strainers, air compressor inlet piping, miscellaneous lubricating oil system piping, and sampling piping after process isolation valves.

  – Lubricating oil piping; carbon steel piping shall be pickled and stainless steel piping shall be swabbed.

  – Fiberglass reinforced plastic piping materials will be used only in applications requiring corrosion-resistant materials.

The above listed materials, or other suitable piping materials listed in Section 3.1, Piping, will be used where required for special service to meet specific requirements.

### 3.1.3 Piping Materials

Piping materials will be in accordance with applicable ASTM, and ASME standards. Materials to be incorporated in permanent systems will be new, unused, and undamaged. Piping materials will be in accordance with the following criteria:

- Steel and Iron Pipe. Carbon steel piping 2-inch nominal size and smaller will be ASTM A53 or A106, Grade B, SCH 80 minimum.

- Carbon steel piping 3 inch through 24-inch nominal size will be ASTM A53 Grade B seamless (welded seam pipe shall be used for low pressure air and water) or A106 Grade B, with the indicated grades as a minimum. Carbon steel piping larger than 24-inch nominal size will be ASTM A672 or API 5L Grade B or ASTM A139 Grade B.

- Low chrome alloy pipe shall be in accordance with ASTM A335 Grades P5, P11, P22 or P91 seamless or welded.

- Stainless steel pipe will be ASTM A312 Grades TP304, TP304L, TP316, or TP 316L seamless or welded. All stainless steel piping materials will be fully solution annealed prior to fabrication. The Type 316 materials will be utilized for high resistance to corrosion. The Type 30 and 316L materials will be utilized for applications requiring hot working (welding, etc.) and for additional corrosion resistance at welds.

- Schedule numbers, sizes, and dimensions of all carbon steel and alloy steel pipe will conform to ASME B36.10M. Sizes and dimensions of stainless steel pipe designated as Schedule 5S, 10S, 40S, or 80S will conform to ASME B36.19M. Schedule numbers, sizes, and dimensions of stainless steel pipe not covered by ASME B36.19M will conform to ASME B36.10.

- Alloy Steel Pipe. Steel piping for acid service shall be Alloy 20.

- Galvanized Steel Pipe. Galvanized carbon steel piping will be ASTM A53 Grade B. The piping will be hot-dip galvanized.

- The use of galvanized steel pipe will be limited to systems where a degree of corrosion resistance is required or where codes require the use of galvanized steel pipe rather than black steel pipe.

- Underground piping materials will be non-metallic, ductile iron or cathodically protected carbon steel (see 3.1.7). The material selection will be in accordance with service requirements. Metallic underground piping will be wrapped in accordance with American Water Works Association (AWWA) standards.

- Polypropylene Lined Pipe. Polypropylene lined pipe will be ASTM A53 steel pipe with an applied liner of polypropylene.

- Fiberglass Reinforced Plastic Pipe. Fiberglass reinforced plastic pipe will be selected accordance with the specific service requirements.

- Polyvinyl Chloride Pipe. Polyvinyl chloride (PVC) pipe will conform to ASTM D1785 or ASTM D2241.

- Chlorinated Polyvinyl Chloride Pipe. Chlorinated polyvinyl chloride (CPVC) pipe will conform to ASTM F441. High Density Polyethylene Pipe. High-density polyethylene pipe will conform to ASTM D3350 with a Plastic Pipe Institute rating of PE 3406 or 3408.

### 3.1.4 Tubing Materials

Tubing materials will generally be in accordance with the following criteria:

- Copper Tubing. Copper tubing ⅜ inch and smaller will be light drawn temper tubing conforming to ASTM B75. Copper tubing, ½ inch and larger, will be ASTM B88 Type K drawn temper.

- Stainless steel tubing will conform to ASTM A213, Type 316. All stainless steel tubing will be of the fully annealed type, with a carbon content greater than 0.04 percent.

- Tubing Wall Thickness. Wall thickness for tubing will be as required for specific design pressure and temperature conditions.

### 3.1.5 Fitting Materials

Fittings will be constructed of materials equivalent to the pipe with which they are used, except for special cases such as lined steel pipe.

- Steel Fittings. Steel fittings 2½ inches and larger will be of the butt welding type and steel fittings 2 inches and smaller will be of the socket welding type, except galvanized steel fittings will be threaded.

- Butt Welding Fittings. The wall thickness of butt welding fittings will be equal to the pipe wall thickness with which they are used. The fittings will be manufactured in accordance with ASME B16.9. ASME B16.28, and ASTM A234 or ASTM A403.

- Forged Steel Fittings. Forged steel fittings will be used for socket weld and steel threaded connections and will conform to ASME B16.11.

- Cast Steel Flanged Fittings. Cast carbon steel flanged fittings will conform to ASME B16.5 and will be of materials conforming to ASTM A216 WCB.

### 3.1.6 Flanges, Gaskets, Bolting, and Unions

Flanged joints will be in accordance with the following requirements:

- Flange Selection:
  - Flanges mating with flanges on piping, valves, and equipment will be of sizes, drilling, and facings which match the connecting flanges of the piping, valves, and equipment.
  - Flange class ratings will be adequate to meet the design pressure and temperature values specified for the piping with which they are used.
  - Flanges will be constructed of materials equivalent to the pipe with which they are used.
  - Mating flanges will be of compatible material.

- Steel Flanges:
  - Steel flanges will conform to ASME B16.5;
  - Carbon steel flanges will be forged in accordance with ASTM A105;
  - Chromium alloy steel and stainless steel flanges will be forged in accordance with ASTM A182.

- Brass and Bronze Flanges. Brass and bronze screwed companion flanges will be plain faced and will conform to Class 150 or Class 300 classifications of ASME B16.24. Drilling will be in accordance with ANSI Class 125 or Class 250 standards. Gaskets will be suitable for the design pressures and temperatures.

- Compressed Fiber Gaskets. Compressed fiber gaskets will be in accordance with ANSI B16.21, and materials will be suitable for a maximum working pressure of 600 psig and a maximum working temperature of 750°F. Compressed fiber gaskets will be used with flat face flanges and raised face slip-on flanges.

- Spiral Wound Gaskets. Spiral wound gaskets will be constructed of a continuous stainless steel ribbon wound into a spiral with non-asbestos filler between adjacent coils. Spiral wound gaskets shall be in accordance with ASME B16.20. Spiral wound gaskets will be used with raised face flanges, except for raised face slip-on flanges.

- Gaskets containing asbestos are not acceptable.

- Gaskets will be suitable for the design pressures and temperatures.

### 3.1.7 Cathodic Protection

Where required, underground piping steel will be cathodically protected, and electrically isolated from above-ground piping and other steel components.

Under ground firewater piping and components, made of steel, will be protected by a cathodic protection system. All cast iron and HDPE piping and components do not require cathodic protection.

### 3.1.8 Piping Fabrication

Piping fabrication will generally be in accordance with the requirements of the Piping Fabrication Institute (PFI).

#### 3.1.8.1 Welder Qualification and Welding Procedures

Welding procedures, welders, and welding operators will be qualified in accordance with ASME Section IX code requirements.

Backing rings will not be allowed for shop or field welds except where specifically permitted.

#### 3.1.8.2 Nondestructive Examination and Inspection

Inspection and testing of piping will be performed in accordance with the requirements of ASME B31.1. Nondestructive examination will generally include visual, radiographic, magnetic particle and liquid penetrant, and ultrasonic examinations.

- Visual examination of welds will be performed by personnel qualified and certified in accordance with AWS QCI, Standard for Qualification and Certification of Welding Inspectors.

- Nondestructive examination shall be performed by personnel certified in accordance with ASNT Recommended Practice SNT-TC-IA.

- Radiographic examination will be performed on welds or welds to pressure retaining components as required by ASME B31.1 LODE.

- Magnetic particle, ultrasonic and liquid penetrant examination will be performed as required by ASME B31.1 Code.

### 3.1.9 Pipe Supports and Hangers

The term "pipe supports" includes all assemblies such as hangers, floorstands, anchors, guides, brackets, sway braces, vibration dampeners, positioners, and any supplementary steel required for pipe supports.

#### 3.1.9.1 Design and Selection Criteria

All support materials, design, and construction will be in accordance with the latest applicable provisions of the Power Piping Code, ASME B31.1. Seismic design of piping systems will be in accordance with criteria as stipulated by the California Building Code.

## 3.2 VALVES

Valve pressure classes, sizes, types, body materials, and end preparations will generally be as described herein. Special features and special application valves will be utilized where required.

Steel body gate, globe, angle, and check valves will be designed and constructed in accordance with ASME B16.34 as applicable.

### 3.2.1 Iron Body Valves

Iron body gate, globe and check valves will have iron bodies and will be bronze mounted. The face-to-face dimensions will be in accordance with ASME B16.10.

### 3.2.2 Butterfly Valves

Rubber-seated butterfly valves will be generally constructed in accordance with AWWA C504 Standard for Rubber-Seated Butterfly Valves. The valves will also generally conform to the requirements of MSS Standard Practice SP-67, Butterfly Valves.

### 3.2.3 Branch Line Isolation Valves

Isolation valves will be provided in 2-inch and smaller branch lines from main piping headers and equipment.

## 3.3 INSULATION AND LAGGING

The insulation and lagging to be applied to piping, equipment, and ductwork for the purposes of reducing heat loss, and personnel protection will be in accordance with the following criteria:

### 3.3.1 Insulation Materials and Installation

Insulation materials will be inhibited and of a low halogen content so that the insulation meets the requirements of ASTM C795 and ASTM C929 regarding stress-corrosion cracking of austenitic stainless steel. Insulation materials will contain no asbestos.

All piping operating above 140°F will be insulated in areas required for personal protection. All piping will be insulated as required for energy conservation, prevention of condensation and noise attenuation.

Equipment and ductwork operating at elevated temperatures will be insulated with calcium silicate or mineral fiber insulation.

### 3.3.2 Lagging Materials and Installation

All insulated surfaces of equipment, ductwork, piping, and valves will be lagged, except where removable covers are used.

### 3.3.3 Freeze Protection

All above ground piping smaller than 2-inch nominal diameter and subject to freezing will be insulated and provided with electric heat tracing. In addition, all piping will be evaluated for freeze protection by the following methods: Insulation, electric heat tracing, low point drains, high point vents and schedule 80 piping.

## 3.4 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 discharged piping and nonreturn 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.

Where necessary, pumping systems with variable flow requirement will have a recirculation line for pump protection. The recirculation lie 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.

For each application, pumps will be sized to accept an impeller at least ⅛ inch larger in diameter than the impeller specified without having to change the casing.

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

The weight of the impeller and shafting for vertically suspended pumps will be supported by the motor thrust bearing.

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.

General service pumps will be purchased to ANSI B73.1.

Firewater Pump, Driver and accessories will be purchased to NFPA 20.

## 3.5 STORAGE TANKS

Water tanks, if required, shall be designed and erected in accordance with AWWA D-100, latest edition. Seismic design will be in accordance with AWWA D-100 requirements. Wind and seismic loadings shall be per CBC. The existing make-up water storage tank provides firewater storage..

The ammonia storage tanks shall be designed and erected in accordance with API.

## 3.6 HEAT EXCHANGERS

The air cooled 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, plate type, or fin-fan coolers. Shell-and-tube heat exchangers will be designed in accordance with TEMA standards. Fouling factors for shell-and-tube exchangers will be in accordance with TEMA practices. The heat exchangers shall be designed and constructed in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, latest edition and addenda.

## 3.7 HEATING, VENTILATING AND AIR-CONDITIONING

Heating, ventilating and air-conditioning (HVAC) systems will be designed and installed in accordance with the California Building Code, Uniform Building Code; Uniform Mechanical Code; American Society of Heating Refrigeration, and Air Conditioning engineers (ASHRAE) Standards; Sheet Metal and Air-Conditioning Contractors National Association (SMACNA) Standards; NFPA 90A and NFPA 101; CCR Title 8 Chapter 4; CCR Title 24; ANSI B31.5, Refrigeration Piping code; and the latest edition of the American Conference of Government Industrial Hygienists, Committee on Industrial Ventilation.

Because HVAC systems bring filtered outside air into control rooms and offices, the interior pressure is greater than atmospheric pressure. Air moves through the openings around doors or windows, or elsewhere, from the higher pressure (inside) to the lower pressure (outside). HVAC system filter efficiency is expected to be approximately 80 percent.

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 be designed to minimize air by-pass and leakage.

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

Grills and louvers will be of metal construction and adjustable.

## 3.8 HEAT RECOVERY STEAM GENERATORS (HRSGS)

The HRSGs shall be designed and constructed in accordance with ASME Boiler and Pressure Vessel Code, Section I, latest edition and addenda. The wind and seismic design criteria shall be in accordance with California Building Code.