Appendix F
Mechanical and Fire Protection Engineering Design Criteria

APPENDIX F MECHANICAL AND FIRE PROTECTION ENGINEERING DESIGN CRITERIA **Page**

1.0 INTRODUCTION F-1

2.0 DESIGN CODES AND STANDARDS F-2

2.1 AMERICAN WATER WORKS ASSOCIATION (AWWA) F-2

2.2 AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS (ASHRAE) F-2

2.3 SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION (SMACNA) F-3

2.4 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) CODES F-3

2.5 AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME) F-5

2.6 AMERICAN SOCIETY FOR NON-DESTRUCTIVE TESTING (ASNT) F-5

2.7 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) F-5

2.8 AMERICAN WELDING SOCIETY (AWS) F-6

3.0 MECHANICAL ENGINEERING GENERAL DESIGN CRITERIA F-7

3.1 PIPING F-7
3.1.1 Design Temperature and Pressure F-7
3.1.2 General Design and Selection Criteria F-7

3.2 PIPING MATERIAL F-8

3.3 TUBING MATERIAL F-8

3.4 FITTING MATERIALS F-9

3.5 CATHODIC PROTECTION F-9

3.6 WELDER QUALIFICATION AND WELDING PROCEDURE F-9
3.6.1 Non-destructive Examination and Inspection F-9

3.7 PIPE SUPPORTS AND HANGERS F-10

3.8 DESIGN AND SELECTION CRITERIA F-10

4.0 VALVES F-11

4.1 IRON BODY VALVES F-11

4.2 BUTTERFLY VALVES F-11

4.3 BRANCH LINE ISOLATION VALVES F-11

5.0 INSULATION AND LAGGING F-12

5.1 INSULATION MATERIALS AND INSTALLATION F-12

5.2 LAGGING MATERIALS AND INSTALLATION F-12

5.3 FREEZE PROTECTION F-12

6.0 STORAGE TANKS – (METAL) F-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 and fire protection design criteria defined herein form the basis of the design for the mechanical and fire protection 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 2.0 of this appendix summarizes the applicable codes and standards, and Section 3.0 of this appendix includes the general design criteria for piping, valves, insulation, lagging, and freeze protection.

2.0 DESIGN CODES AND STANDARDS

The design and specification of all work shall be in accordance with all applicable laws, ordinances, regulations, codes and standards (LORS) of the federal government, the State of California, local and regional governmental agencies, and generally accepted industry standards organizations. Applicable LORS to be used in design and construction of the SOLAR TWO include, but are not limited to, those published by the following entities:

2.1 AMERICAN WATER WORKS ASSOCIATION (AWWA)

- D103-97: Factory-Coated Bolted Steel Tanks for Water Storage
- ANSI/AWWA D100, Standard for Welded Steel Tanks for Water Storage
- C504 Standard for Rubber-Seated Butterfly Valves

2.2 AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS (ASHRAE)

- ANSI/ASHRAE 15-2004 - Safety Standard for Refrigeration Systems
- ANSI/ASHRAE 16-1983 (RA 99) - Method of Testing for Rating Room Air Conditioners and Packaged Terminal Air Conditioners
- ANSI/ASHRAE 33-2000 - Method of Testing Forced Circulation Air Cooling and Air Heating Coils
- ANSI/ASHRAE 34-2001 - Designation and Safety Classification of Refrigerants
- ANSI/ASHRAE 34-2004 - Designation and Safety Classification of Refrigerants
- ANSI/ASHRAE 37-2005 - Methods of Testing for Rating Unitary Air Conditioning and Heat-Pump Equipment
- ANSI/ASHRAE 55-2004 - Thermal Environmental Conditions for Human Occupancy
- ANSI/ASHRAE 62.1-2004 - Ventilation and Acceptable Indoor Air Quality
- ANSI/ASHRAE 68-1997 (ANSI/AMCA 330-97) - Laboratory Method of Testing to Determine the Sound Power in a Duct
- ANSI/ASHRAE 70-1991 - Method of Testing for Rating the Performance of Air Outlets and Inlets
- ANSI/ASHRAE 74-1988 - Method of Measuring Solar-Optical Properties of Materials
- ANSI/ASHRAE/EIESNA 90.1-2004 - Energy Standard for Buildings Except Low-Rise Residential Buildings (SI edition)
- ANSI/ASHRAE 114-1986 - Energy Management Control Systems Instrumentation

- ANSI/ASHRAE 120-1999 - Method of Testing to Determine Flow Resistance of HVAC Ducts and Fittings
- ANSI/ASHRAE/SMACNA 126-2000 - Method of Testing HVAC Air Ducts
- ANSI/ASHRAE 127-2001 - Method of Testing for Rating Computer and Data Processing Room Unitary Air-Conditioners
- ANSI/ASHRAE 130-1996 - Methods of Testing for Rating Ducted Air Terminal Units
- ANSI/ASHRAE Guideline 0-2005 - The Commissioning Process
- ASHRAE Guideline 4-1993 - Preparation of Operating and Maintenance Documentation for Building Systems
- ASHRAE Guideline 13-2000 - Specifying Direct Digital Control Systems
- ASHRAE Guideline 14-2002 - Measurement of Energy and Demand Savings
- ASHRAE Guideline 16-2003 - Selecting Outdoor, Return, and Relief Dampers for Air Side Economizer Systems

2.3 SHEET METAL AND AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION (SMACNA)

- Seismic Restraint Manual - Guidelines for Mechanical Systems, Second Edition- 1998
- SMACNA "HVAC Systems-Duct Design"
- SMACNA "HVAC - Systems-Applications"
- SMACNA "HVAC Systems- Testing, Adjusting and Balancing

2.4 NATIONAL FIRE PROTECTION ASSOCIATION (NFPA) CODES

- NFPA 1 Uniform Fire Code 2006 Edition
- NFPA 10 Standard for Portable Fire Extinguishers 2007 Edition
- NFPA 13 Standard for the Installation of Sprinkler Systems 2007 Edition
- NFPA 14 Standard for the Installation of Standpipe and Hose Systems 2007 Edition
- NFPA 20 Standard for the Installation of Stationary Pumps for Fire Protection 2007 Edition
- NFPA 22 Standard for Water Tanks for Private Fire Protection 2003 Edition
- NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances 2007 Edition

- NFPA 25 Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems 2002 Edition
- NFPA 30 Flammable and Combustible Liquids Code 2003 Edition
- NFPA 30A Code for Motor Fuel Dispensing Facilities and Repair Garages 2003 Edition
- NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines 2006 Edition
- NFPA 51B Standard for Fire Prevention During Welding, Cutting, and Other Hot Work 2003 Edition
- NFPA 52 Vehicular Fuel Systems Code 2006 Edition
- NFPA 51B Standard for Fire Prevention During Welding, Cutting, and Other Hot Work 2003 Edition
- NFPA 55 Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks 2005 Edition
- NFPA 72 National Fire Alarm Code® 2007 Edition
- NFPA 75 Standard for the Protection of Information Technology Equipment 2003 Edition
- NFPA 76 Standard for the Fire Protection of Telecommunications Facilities 2005 Edition
- NFPA 77 Recommended Practice on Static Electricity 2007 Edition
- NFPA 80 Standard for Fire Doors and Other Opening Protectives 2007 Edition
- NFPA 80A Recommended Practice for Protection of Buildings from Exterior Fire Exposures 2007 Edition
- NFPA 90A Standard for the Installation of Air-Conditioning and Ventilating Systems 2002 Edition
- NFPA 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems 2006 Edition
- NFPA 101® Life Safety Code® 2006 Edition
- NFPA 110 Standard for Emergency and Standby Power Systems 2005 Edition
- NFPA 220 Standard on Types of Building Construction 2006 Edition

2.5 AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

- ANSI/ASME B16.9 Factory-Made Wrought Buttwelding Fittings
- ANSI/ASME B16.10 Face-to-Face and End-to-End Dimensions of Valves
- ANSI/ASME B16.11 Forged Steel Fittings, Socket-Welding and Threaded
- ANSI/ASME B16-15 Cast Bronze Threaded Fittings
- ANSI/ASME B16.24 Cast Copper Alloy Pipe Flanges and Flanged Fittings
- ANSI/ASME B16.28 Wrought Steel Buttwelding Short Radius Elbows and Returns
- ANSI/ASME B31.1 - Power Piping, 2007 edition
- ASME/MSS Standard Practice SP-67, Butterfly Valves
- ASME/BPVC-IX BPVC Section IX –Welding and Brazing Qualifications

2.6 AMERICAN SOCIETY FOR NON-DESTRUCTIVE TESTING (ASNT)

- ASNT Recommended Practice SNT-TC-IA OK20

2.7 AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- ASTM A53/A53M Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- ASTM A106/A106M Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
- ASTM A213/A213M Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes
- ASTM A234/A234M Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
- ASTM A403/A403M Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
- ASTM B43 Standard Specification for Seamless Red Brass Pipe, Standard Sizes
- ASTM B75 Standard Specification for Seamless Copper Tube
- ASTM B88 Standard Specification for Seamless Copper Water Tube
- 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 Plastics Pipe and Fittings Materials
- ASTM F441/F441M Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe,

2.8 AMERICAN WELDING SOCIETY (AWS)

- AWS QCI, Standard for Qualification and Certification of Welding Inspectors

3.0 MECHANICAL ENGINEERING GENERAL DESIGN CRITERIA

3.1 PIPING

Piping for the raw water, water treatment, fire protection, and building services 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 will be consistent with conditions established for the design of the associated system. The design pressure of a piping system will be based generally on either the maximum sustained pressure that may act on the system, plus 10 percent, or to the relief valve. The design temperature of a piping system generally will be based on the maximum sustained temperature which may act on the system plus 50 deg. F rounded up to the next 5 deg. F increment.

3.1.2 General Design and Selection Criteria

Piping will be designed in accordance with the requirements of the Code for Pressure Piping, ANSI B31.1-Power Piping and other codes and standards referenced in Section 2.0 of this Appendix, Codes and Standards. Pipe stress analysis will be performed in accordance with ASME / ANSI B31.1. All pipe supports will be suitable to restrain the piping where subjected to external loads as stipulated by the Uniform Building Code - Seismic and Wind Load Criteria.

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 800 deg. F
- Scale free piping materials such as cleaned carbon steel, stainless steel or non-metallics will be used in piping applications requiring a high degree of cleanliness generally including water treatment, air compressor inlet piping and miscellaneous lubricating oil system piping

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

3.2 PIPING MATERIAL

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:

- Carbon steel piping 2-inch nominal size and smaller will be ASTM A53 or A106, Grade B.
- Carbon steel piping 2-1/2 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.
- Underground piping materials will be non-metallic, ductile iron, concrete or 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.
- Copper alloy pipe will conform to ASTM B43 Seamless Red Brass Pipe.
- Polyvinyl chloride (PVC) pipe will conform to ASTM D1785 or ASTM D2241.
- Chlorinated polyvinyl chloride (CPVC) pipe will conform to ASTM F441.
- High-density polyethylene pipe will conform to ASTM D3350 with a Plastic Pipe Institute rating of PE 3406 or 3408.

3.3 TUBING MATERIAL

Tubing materials will be in accordance with the following criteria:

- Copper tubing 3/8 inch and smaller will be light drawn temper tubing conforming to ASTM B75. Copper tubing, 1/2 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.

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

3.4 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 2-1/2 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 Welded Fittings. The wall thickness of butt weld fittings will be equal to the pipe wall thickness with which they are used. The fittings will be manufactured in accordance with ANSI B16.9. ANSI 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 ANSI Bl6.11.
- Brass and Bronze Fittings. Screwed brass and bronze pipe fittings will conform to ANSI B16-15. Flanged brass and bronze pipe fittings will conform to ANSI B16.24.

3.5 CATHODIC PROTECTION

Cathodically protected, underground steel piping will be electrically isolated from above ground piping and other steel components. Isolation will be achieved by installation of isolation flanges with insulating gaskets, tubes, and washers.

3.6 WELDER QUALIFICATION AND WELDING PROCEDURE

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 required for structural purposes.

3.6.1 Non-destructive Examination and Inspection

Inspection and testing of piping will be performed in accordance with the requirements of ASME B31.1. Non-destructive 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.

- Non-destructive 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.

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

3.7 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 to attach pipe supports.

3.8 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 (CBC).

4.0 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 ANSI B16.34 as applicable.

4.1 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 ANSI B16.10.

4.2 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.

4.3 BRANCH LINE ISOLATION VALVES

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

5.0 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.

5.1 INSULATION MATERIALS AND INSTALLATION

All piping operating above 140 deg. 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.

5.2 LAGGING MATERIALS AND INSTALLATION

All insulated surfaces of equipment, ductwork, piping, and valves will be lagged.

5.3 FREEZE PROTECTION

All aboveground water and steam piping will be arranged, to the maximum extent possible, to allow drainage to protect the pipe from freezing. Electrical heat tracing may be used if required.

6.0 STORAGE TANKS – (METAL)

Water tanks shall be designed and erected in accordance with AWWA D-100, latest edition. Seismic design will be in accordance with AWWA D-100 requirements and the wind loading will be in accordance with the CBC.