Appendix K
Hydrogen System Design Criteria

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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, standards, standard design criteria and practices that will be used during the project. The general hydrogen system design criteria defined herein form the basis of the design for the hydrogen system. 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 SunCatcher tanks, SunCatcher fill piping, SunCatcher filling, and cylinder storage.

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:

- ANSI - American National Standards Institute
  - ANSI/NFPA 70 - National Electrical Code (NEC)
  - ANSI Bl.1 - Unified Inch Screw Threads (UN and UNR thread form)
  - ANSI B2.1 - Pipe Threads Except Dryseal
  - ANSI B16.5 - Pipe Flanges and Flanged Fittings, Steel Nickel Alloy and Other Special Alloys
  - ANSI B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges
  - ANSI B16.34 - Valves - Flanged, Threaded and Welding End
  - ANSI B18.2.1 - Square and Hex Bolts and Screws, Inch Series
  - ANSI B36.19 - Stainless Steel Pipe
- ASME - American Society of Mechanical Engineers Boiler and Pressure Vessel Code:
  - Section II - Materials Specification
  - Section V – Non-destructive Examination
  - Section VIII - Rules for Construction of Pressure Vessels
  - Section IX - Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators
  - PTC 22 - Performance Test Code
  - ASNT - American Society for Non-destructive Testing
- ASTM - American Society for Testing and Materials
  - 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 Material for High Temperature or High Pressure Service or Other Special Purpose Applications

  - ASTM A312-Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
  - ASTM A403-Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
  - ASTM A999-Standard Specification for General Requirements for Alloy and Stainless Steel Pipe
  - ASTM A1016-Standard Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel and Stainless Steel Tubes
- California Code of Regulations
  - Title 8, Industrial Relations, Chapter 4, Industrial Safety
- CFR – Code of Federal Regulations
  - Title 29, Labor, Part 1910 – Occupational Health and Safety Standards
  - Title 49, Transportation, Parts 100-199 – Hazardous Materials
  - Title 29, Inspections & Test, parts 180.406-409, and 178.320(a)
- CGA – Compressed Gas Association
  - CGA G-5, Hydrogen
  - CGA P-1, Safe Handling of Compressed Gas in Containers
- EPA - Environmental Protection Agency
- HEI - Heat Exchange Institute
- ISA - Instrument Society of America
- NBS - National Bureau of Standards
- NFPA - National Fire Protection Association codes
  - NFPA 55, Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders and Tanks
  - NFPA 101, Life Safety Code
- OSHA – Occupational Safety and Health Administration
- PFI - Pipe Fabrication Institute
- UFC - Uniform Fire Code
- UL - Underwriter Laboratory

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 edition and/or addenda to all applicable LORS that has been adopted and is in place at time of plant design and construction shall apply to work performed for this Facility.

3.0 HYDROGEN SYSTEM GENERAL DESIGN CRITERIA

The SunCatcher hydrogen tank and piping system is a pre-manufactured system that will be delivered to the site for assembly. Personnel familiar with proper practices with reference to their construction and use will supervise the assembly. The assembly will be protected against physical damage and against tampering during delivery and installation. All hydrogen tanks and systems constructed in accordance with a DOT specification for which a test or inspection specified will become due, may not be filled and offered for transportation or transported until the test or inspection has been successfully completed. Any inspected tank or system will have an inspector that is qualified and certified by 29 CFR 180.409 procedure 29 CFR 180.407.

3.1 SUNCATCHER TANK

The SunCatcher uses the Stirling Engine Process. This requires hydrogen as the working fluid of the engine. The use and storage of hydrogen will be internal to the Stirling Engine, a ballast tank, and a storage tank. These three components drive the Stirling Cycle onboard the SunCatcher.

3.2 SUNCATCHER FILL PIPING

The SunCatcher fill piping, tubing and fittings will be suitable for hydrogen service and for the pressure and temperatures involved. Cast iron pipe and fittings will not be used. The pipe and tubing will comply with ANSI B36.19. Joints in piping and tubing will be made by welding or brazing or by use of flanged, threaded, socket or compression fittings. Gaskets and thread sealants will be suitable for hydrogen service.

3.3 SUNCATCHER TANK FILLING REQUIREMENTS

Only experienced and properly instructed personnel will handle compressed gases. During filling, the cylinders will be secured in an upright position. The valve protection cap will be removed only just before connecting the cylinder to the manifold. The cylinder units will be electrically bonded to the system before discharging hydrogen. Personnel will ensure all connection will remain gas-tight during filling.

3.4 CYLINDER STORAGE

Cylinder storage will be in compliance with the requirements of Compressed Gas Association pamphlet P-1, Safe Handling of Compressed Gases in Containers.

The stored cylinders will be legibly marked with the name "Hydrogen" and proper identification labels. The identification labels applied by the gas supplier will be the primary identifier; not the color of the container.

The storage areas will be prominently posted with the hazard class and gas identified. No smoking and no open flame signs will be posted.

The storage areas will be designed to accommodate the cylinder containers with adequate spacing and segregation by partitioning. Empty and full containers will be stored separately. The areas will be above grade, well-drained, well-ventilated with adequate separation from combustibles. The storage area will consist of a paved asphalt or concrete surface that has been graded to prevent accumulation of water. The cylinders will not be subject to prolonged exposure to damp environments. Structures used for shielding and shading will be fire-resistive. The cylinders will be stored in a fenced area to protect against tampering and damage. The cylinders will not be stored near readily ignitable substances or exposed to corrosive chemicals or fumes. The cylinders will be protected from objects that can produce harmful cuts or abrasions in the surface of the metal. The cylinders will not be stored in a location where heavy moving objects can strike or fall on them. The cylinders will be kept at pressures and temperatures not to exceed normal operating parameters. The storage areas will not exceed 125 degrees Fahrenheit ambient.

The cylinders will be stored in a secured position to prevent falling or rolling. The cylinders will be nested to maintain a 3-point contact grounding system or a grounding wire will be connected and used in all storage cylinders.. Valve protection caps will be used and applied hand tight.

The cylinders will be stored in a secure area with access limited to authorized personnel only. Product inventory will be maintained. All inventory discrepancies will be investigated. All incidents involving thefts, misuse or inventory shortages will be reported to law enforcement and to the supplier.

Periodic test and inspection. Each specification cargo tank must be tested and inspected as specified in table by an inspector meeting the qualifications in 29CFR § **180.409** . The retest date shall be determined from the specified interval identified in table from the most recent inspection or the CTMV certification date.