Engineering Standard

SAES-D-100 31 December, 2003

Design Criteria of Atmospheric and Low-Pressure Tanks

Saudi Aramco DeskTop Standards

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1 Scope

1.1 This standard defines the minimum mandatory requirements governing the selection and mechanical design of atmospheric and low-pressure storage tanks in accordance with API STD 650, Tenth Edition (November 1998) with Addendum 3 (September 2003) or API STD 620, Tenth Edition (February 2002), as applicable. This standard also defines the requirements for horizontal storage tanks in low-pressure service.

1.2 Tanks designed in accordance with Appendix Q "Low-Pressure Storage Tanks for Liquefied Hydrocarbons Gases" and double wall tanks according to Appendix R "Low-Pressure Storage Tanks for Refrigerated Products" of API STD 620 are not covered by this standard. Additional requirements for such tanks shall be developed, if necessary, by the Design Engineer for review by the Saudi Aramco Engineer.

1.3 This standard shall be used by the Design Engineer to complete the tank data sheets.

1.4 This standard shall not be attached to nor made a part of purchase orders.

2 Conflicts and Deviations

2.1 Any conflicts between this standard and other applicable Saudi Aramco Engineering Standards (SAESs), Materials System Specifications (SAMSSs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this standard in writing to the Company or Buyer Representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

The selection and design of equipment and facilities covered by this standard shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Reports

SAER – 5800	*Use of Aluminum Geodesic Dome Roofs on External Floating Roof Tanks*

Saudi Aramco Engineering Standards

SAES-A-005	*Safety Instruction Sheet*
SAES-A-102	*Air Pollutant Emission Source Control*
SAES-A-112	*Meteorological and Seismic Design Data*
SAES-B-005	*Spacing and Diking for Atmospheric and Low-Pressure Tanks*
SAES-B-017	*Fire Water System Design*
SAES-B-018	*Air Foam Systems for Storage Tanks*
SAES-B-054	*Access, Egress, and Materials Handling for Plant Facilities*
SAES-B-055	*Plant Layout*
SAES-B-057	*Safety Requirements: Refrigerated and Pressure Storage Vessels*
SAES-H-001	*Selection Requirements for Industrial Coatings*
SAES-H-101	*Approved Protective Coating Systems*
SAES-J-300	*Level*
SAES-J-600	*Pressure Relief Devices*
SAES-M-001	*Structural Design Criteria for Non-Building Structures*
SAES-N-001	*Basic Criteria, Industrial Insulation*
SAES-P-111	*Grounding*
SAES-P-123	*Lighting*
SAES-Q-005	*Concrete Foundations*
SAES-X-500	*Cathodic Protection of Vessels and Tank Internals*
SAES-X-600	*Cathodic Protection of Plant Facilities*

Saudi Aramco Materials System Specifications

32-SAMSS-005	*Manufacture of Atmospheric Tanks*
32-SAMSS-006	*Manufacture of Low-Pressure Tanks*
32-SAMSS-017	*Side-Entry Mixers*

Saudi Aramco Standard Drawings

AA-036256	*General Assembly of Radar, Temperature, and Manual Gauging for External Floating Roof Tanks*
AA-036504	*Assembly and Details of Gage Well and Guide Pole For Floating Roof Tanks*
AB-036003	*Manholes and Vents for Tanks*
AD-036061	*Roof Center Vent for Cone Roof Tanks*
AA-036355	*Impressed Current Tank Bottom Cathodic Protection Details*
AB-036387	*Tank Grounding*

Saudi Aramco Forms and Data Sheets

SA 2693-ENG	*Tank Safety Instruction Sheet*
SA 2694-ENG	*Pressure Vessel Safety Instruction Sheet*
SA 2696-ENG	*Appurtenance Schedule and Orientations*
SA 9527-ENG	*Pressure Vessel Design Sheet*
SA 9580-ENG	*API STD 620 Storage Tank Data Sheet*

3.2 Industry Codes and Standards

American Petroleum Institute

API STD 620	*Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks*
API STD 650	*Welded Steel Tanks for Oil Storage*
API STD 2000	*Venting Atmospheric and Low-Pressure Storage Tanks*
API RP 2003	*Protection Against Ignitions Arising out of Static, Lightning and Stray Currents*
API STD 2510	*Design and Construction of LPG Installations*
API PUBL 2510A	*Fire-Protection Considerations of the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities*

American Society of Civil Engineers

ASCE 7 - 95	*Minimum Design Loads for Buildings and Other Structures*

American Society of Mechanical Engineers Boiler and Pressure Vessel Code

ASME SEC VIII D1	*Rules for Construction of Pressure Vessels*

American Society for Testing and Materials

ASTM D323	*Standard Test Method for Vapor Pressure of Petroleum Products (Reid Method)*

National Fire Protection Association

NFPA 68	*Guide for Venting of Deflagrations*
NFPA 255	*Standard Method of Test of Surface Burning Characteristics of Building Materials*

4 Definitions

Atmospheric Pressure: An internal pressure that results in total uplift force not exceeding the weight of the tank roof.

Auto Refrigeration Temperature: Auto-refrigeration temperature is the adiabatic vaporization temperature of the process fluid coincident with a pressure equal to 25% of the maximum operating pressure.

Design Engineer: The Engineering Company responsible for specifying, on the design data sheet, the design requirements for tanks.

Low-Flash Liquids: Hydrocarbon liquids with a flash point below 54°C (129°F) or within 8°C (14.4°F) of their flash point. Crude oils are not included in this category.

Low-Pressure: An internal pressure that exceeds the weight of the tank roof but does not exceed 103 kPa gauge (15 psig).

Reid Vapor Pressure: The vapor pressure of hydrocarbon liquids at 38°C (129°F) as measured in accordance with ASTM D323.

Saudi Aramco Engineer: The Supervisor of the Process Equipment Unit, Consulting Services Department, Dhahran.

Tank Manufacturer: The Company responsible for the design and fabrication of tanks.

5 Responsibilities

5.1 The Design Engineer is responsible for specifying the type, size and design conditions for storage tanks, including the requirements for associated tank appurtenances and cathodic protection.

5.2 The Tank Manufacturer is responsible for the design, supply of materials, fabrication, erection, inspection, testing, surface preparation and painting of tanks in accordance with the Design Engineer's specification.

6 Tank Selection

6.1 External (open-top) floating roof tanks in accordance with API STD 650 shall be specified for the following services:

1) Crude oil (stabilized);

2) Low-flash liquids;

3) Liquids having a Reid vapor pressure from 14 kPa absolute (2 psia) to 76 kPa absolute (11 psia) with true vapor pressure not exceeding 90 kPa (13 psia).

4) Liquids that are classified as electrostatic accumulators and are likely to produce a flammable vapor-air mixture in the vapor space of the tank such as Jet fuels.

6.2 Internal floating roof tanks in accordance with API STD 650 shall be specified for the following services:

1) Services listed in Paragraph 6.1 when small storage volumes are required and the use of internal floating roof tanks is more economical than external floating roof tanks.

2) Services when product contamination from weather elements is to be minimized.

3) Services where existing fixed roof tanks are to be converted to internal floating roof tanks to minimize evaporation losses and/or emissions.

6.3 Neither external nor internal floating roof tanks shall be used for storing cutback asphalt.

6.4 Fixed roof tanks shall be used for tanks with internal floating roofs and for all services other than those specified in paragraph 6.1.

6.5 Low-pressure storage tanks in accordance with API STD 620 shall be specified for the services listed below:

1) Unstabilized crude oil;

2) Petroleum products that boil under atmospheric conditions;

3) Refrigerated products.

7 Materials

7.1 Materials of all tank's components shall be selected in accordance with 32-SAMSS-005 or 32-SAMSS-006, as applicable.

7.2 Use of materials other than to those listed in 32-SAMSS-005 and 32-SAMSS-006 requires approval of the Saudi Aramco Engineer.

7.3 The impact testing of tank's components shall be determined by the Tank Manufacturer based on the material minimum design metal temperature (MDMT), in accordance with the requirements specified in 32-SAMSS-005 or 32-SAMSS-006, as applicable.

7.4 Corrosion Allowance

7.4.1 For atmospheric pressure tanks storing crude oil or petroleum products, no corrosion allowance is required, unless specified by the Proponent Department.

7.4.2 For tanks storing water, a corrosion allowance shall be specified as follows:

1) 1.6 mm (1/16 inch) shell corrosion allowance for tanks without cathodic protection;

2) 1.6 mm (1/16 inch) for roof supports, such as columns, rafters and girders;

3) No corrosion allowance is required for roof and bottom plates.

7.4.3 For low-pressure tanks designed in accordance with API STD 620, corrosion allowance shall be specified as follows:

1) 1.6 mm (1/16 inch) for all pressure parts, shell stiffeners and roof support members;

2) 3.2 mm (1/8 inch) on diameter of anchor bolts;

3) No corrosion allowance is required for hold down straps.

8 Design

8.1 General

8.1.1 The Design Engineer shall complete the data sheet for the tank being purchased in accordance with this standard as follows:

1) For API STD 650 tanks, use the Storage Tank Data Sheet in Appendix L of API STD 650 and provide the additional information as detailed in Appendix L of this standard.

2) For API STD 620 tanks, use Saudi Aramco Form 9580-ENG.

3) For Horizontal, cylindrical, low-pressure tanks, prepare an appropriate data sheet for this type of tank or use Saudi Aramco Form 9527-ENG.

8.1.2 The Design Engineer shall complete Saudi Aramco Form 2696-ENG showing the tank dimensions, appurtenance schedules, orientations and elevations for API STD 650 and API STD 620 Tanks.

8.2 Design Criteria

8.2.1 Atmospheric storage tanks shall be mechanically designed, fabricated, erected, inspected, and tested in accordance with API STD 650 and applicable appendices, 32-SAMSS-005, and this standard.

8.2.2 Low-pressure storage tanks, including those for refrigerated products, shall be mechanically designed, fabricated, erected, inspected, and tested in accordance with API STD 620 and applicable appendices, 32-SAMSS-006, and this standard.

8.2.3 Tanks that are designed for internal pressure within the scope of API STD 650 Appendix F shall meet the requirements of API STD 650, Appendix F, 32-SAMSS-005 and this standard.

8.2.4 Low-pressure, horizontal, cylindrical tanks shall be mechanically designed using the rules of ASME SEC VIII D1.

8.3 Tank Dimensions and Capacity

8.3.1 The Design Engineer shall determine the initial tank dimensions based on the most economical tank height versus diameter, taking into considerations the following factors:

1) Allowable soil/foundation load;

2) Anticipated soil/foundation settlement;

3) Spacing requirements between tanks in accordance with SAES-B-005.

The Design Engineer shall verify that the Tank Manufacturer's design proposal meets the specified dimensional requirements.

8.3.2 Net working capacity shall be calculated based on the nominal capacity minus the innage (non-withdrawable bottom) and outage (non-usable top) of the tank.

8.4 Design Conditions

8.4.1 The minimum design metal temperature, for the purpose of determining the material toughness requirements, shall be the lowest of the following values:

1) The lowest one-day mean atmospheric temperature (LODMAT) per SAES-A-112, or

2) The minimum operating temperature, or

3) The hydrostatic test temperature.

4) Auto-refrigeration temperature for refrigerated storage tanks as defined in section 4 of this standard.

8.4.2 The design temperature shall not exceed the metal temperature limitations specified in the applicable Code.

8.4.3 The design pressure for low-pressure horizontal cylindrical tanks shall not exceed 103 kPag (15 psig) in accordance with API STD 620.

8.4.4 The specific gravity of the test water shall be specified, if greater than 1.0.

8.5 External Loads

8.5.1 The basic wind speed corresponding to the tank site shall be specified in accordance with SAES-A-112. Design wind loads shall be determined using the criterion specified in SAES-M-001, paragraph 5.5.

8.5.2 The seismic zone factor, importance factor and the site coefficient corresponding to the tank site shall be specified in accordance with SAES-A-112. The Importance Factor "I" shall be Category IV per ASCE 7 - 95.

8.5.3 Nozzle loads from connected piping to shell nozzles shall be specified for tanks larger than 36 m (120 ft) in diameter and nozzles 152 mm (6 inch) NPS and greater.

8.6 Shells

8.6.1 A freeboard shall be specified above the design liquid level for external floating roof tanks. The freeboard shall be sufficient to fully contain within the shell the sealing ring and the secondary seal.

8.6.2 A freeboard shall be specified above the design liquid level for fixed roof tanks with internal floating roofs. The freeboard shall be sufficient to fully contain the sealing ring below the shell-to-roof juncture.

8.7 Roofs

8.7.1 External Floating Roofs

1) Single deck pontoon type floating roofs shall be specified for tank diameters up to and including 92 m (300 ft) tank diameter. The deck shall be of the contact type with minimum vapor space.

2) Double deck pontoon type floating roofs shall be specified for tank diameters greater than 92 m (300 ft).

3) Double deck pontoon type floating roofs are acceptable for small floating roof tanks if they are more economical than single deck pontoon type floating roofs.

4) Secondary seals shall be provided when required by to SAES-A-102.

8.7.2 Internal Floating Roofs

The acceptable types of internal floating roofs are as follows:

1) Metallic pontoon roofs in contact with the liquid and have closed pontoons.

2) Metallic roofs on floats with the deck above the liquid.

3) Metallic double deck roofs in contact with the liquid.

8.7.3 Fixed Roofs

8.7.3.1 For insulated tanks, the design of the roof-to-shell juncture shall prevent the infiltration of rainwater into the insulation.

8.7.3.2 Self-supporting aluminum dome roof (ADR) shall be considered in lieu of a conventional fixed roof with a supporting system, which includes multiple rings of supporting columns with girders and rafters, for tanks with diameters of 30 m (100 ft) or more. This is applicable for fixed roof tanks with and without internal floating roofs.

Commentary: Refer to SAER – 5800 "Use of Aluminum Geodesic Dome Roofs on External Floating Roof tanks" for more details on the advantages of utilizing ADR.

8.8 Bottoms

8.8.1 Vertical, cylindrical, flat bottom tanks built to API STD 620 and API STD 650 shall have 1 in 120 upward-sloped bottoms.

8.8.2 Aviation fuel tanks built to API STD 650 shall have a 3-degree upward-sloped bottom. Alternatively, such tanks can have 1 in 120 downward-sloped bottoms.

8.9 Supports for Low-Pressure Storage Tanks

8.9.1 Horizontal vessel shall be supported by two saddles. The vessel shall be fixed at one saddle and free to move in the longitudinal direction, due to thermal and pressure differentials, at the other saddle.

8.9.2 Tank data sheet shall specify locations of the fixed and sliding saddles and dimension from vessel centerline to underside of saddle base plate.

9 Appurtenances

9.1 General

The type, quantity and layout of all appurtenances for storage tanks shall be specified in accordance with this standard.

9.2 Nozzles and Manways

9.2.1 Nozzle and piping sizes 32 mm (1-¼ inch), 36 mm (2-½ inch), 89 mm (3-½ inch) and 127 mm (5 inch) NPS shall not be used.

9.2.2 Inlet and outlet nozzles may be located in tank shell or tank bottom. The use of bottom nozzles shall be approved by the Saudi Aramco Engineer if the predicted bottom settlement exceeds 12.7 mm (0.5 inch) at the nozzle locations.

9.2.3 Nozzles 2 inch NPS and larger in API STD 650 tanks shall be flanged.

9.2.4 Nozzle connections in API STD 620 tanks shall be flanged. Threaded and socket-welded connections are prohibited.

9.2.5 Connections 38 mm (1-½ inch) NPS and smaller shall be Class 3000 minimum, either socket welded or threaded full couplings.

9.2.6 Shell and roof manways shall be specified in accordance with SASD AB-036003.

9.2.7 Nozzle flanges mating with valves having flat-faced flanges shall be specified as flat-faced.

9.3 Piping and Manifolds

9.3.1 Block valves shall be installed directly at the tank nozzles. If more than one line connects to the same nozzle, valves shall be installed in each line, in addition to the nozzle block valve.

9.3.2 Where the tank cannot be emptied directly into an underground sewer system, a 100 mm (4-inch) NPS flanged and blinded valve shall be installed on the fill line 3.28 m (10 ft) from the tank.

9.3.3 Pump-out connections shall be provided on lines 300 mm (12-inch) NPS and larger at the lowest point of the line and shall consists of a 100 mm (4-inch) NPS flanged and blinded valve.

9.3.4 An inlet diffuser shall be specified for tanks with internal floating roofs with the following requirements:

9.3.4.1 The inlet diffuser shall be sized based on the maximum pumping in rate and the maximum permissible exit velocity through the slots in the diffuser.

9.3.4.2 The diffuser shall be slotted. The slots shall be located at 60 degrees (2 o'clock and 10 o'clock positions) from the vertical centerline of the diffuser.

9.3.4.3 The number and dimensions of slots shall be calculated so that the exit velocity does not exceed 1 m/sec (3.28 ft/sec) at the maximum inlet flow until there is a minimum of 1m (40 inch) of liquid cover over the inlet.

9.3.5 Bellows expansion joints shall not be used in tank piping.

9.3.6 Cast iron valves shall not be used.

9.4 Floating Suction Lines

9.4.1 Floating suction lines shall be specified if required in consultation with the operating unit at the specific facility. Tanks that store products such as aviation fuel may require floating suction lines to allow extraction at high levels if settlement time is limited after filling and before product delivery is required.

9.4.2 When floating suction lines are specified, flexible hoses shall not be used.

9.5 Vents

9.5.1 Venting requirements shall be specified in accordance with API STD 2000, SAES-J-600, SASDs AB-036003 and AD-036061 and the following requirements:

9.5.1.1 Fixed roof tanks with internal floating roofs shall be treated as fixed roof tanks when determining the venting capacity requirements for the internal floating roof.

Commentary Note:

Individual venting devices/arrangement shall be provided for the fixed roof and the internal floating roof, when circulation vents are not installed, according to API STD 2000 requirements.

9.5.1.2 Floating roofs

9.5.1.2.1 As a minimum, two overpressure/vacuum bleeder type vents shall be installed. Vents shall be sized to handle a total of 125% of the maximum filling/withdrawal rates that are specified on the Storage Tank Data Sheet.

Commentary Note:

Bleeder vents shall be designed to open and close automatically when the roof is 75 mm above its low support legs position upon emptying and filling the tank, respectively.

9.5.1.2.2 Vents for protection against overpressure/vacuum, while the roof is floating, shall be provided as follows:

1) Their overall capacity shall be determined according to API standard 2000 requirements, considering 25% of the filling/emptying rates and 100% of thermal breathing.

2) Vents shall be evenly distributed and close to the roof periphery enough vents shall be provided close to the inlet diffuser in services where gas slugs are expected.

3) Vents shall be designed so as not to allow any carry over of stored liquid onto the floating roof.

Commentary Notes:

i) Normally, vents are of the open type that does not undergo testing but rather in-situ inspection. In case relief valves are used, their number shall be such that the total required venting capacity is always available when a number of valve(s) are removed for testing.

ii) Anticipated operation upset conditions such as an increase in temperature of the input stream to a tank or chemical injection that will result in vaporization beyond that associated with the product true vapor pressure design limit of 90 kPa absolute (13 psia) or gas purges shall be also considered in determining the required venting capacity.

9.5.2 Emergency venting capacity per API STD 2000 and explosion hatch per NFPA 68 shall be provided for API STD 650 fixed roof tanks. A frangible shell-to-roof joint may be considered as an alternative to additional venting devices that are normally provided to relieve excess pressure during emergency conditions for tanks of diameters equal to or larger than 15.24 m (50 feet). Frangible shell-to-roof joint shall conform to the requirements of API STD 650.

9.5.3 The pressure and vacuum vent settings shall be specified on the tank data sheet.

9.6 Mixers

9.6.1 Mixing equipment shall be specified as follows:

1) Crude tanks

Side entry propeller type mixers shall be specified for all crude tanks.

2) Product tanks which contain a stock produced by the blending of two or more components and/or additives.

A jet nozzle with a recirculation system or a propeller type mixer shall be specified.

3) Blend stock tanks

The rundown line shall be equipped with a jet nozzle.

4) Intermediate tanks

The rundown line shall be equipped with a jet nozzle. A recirculation system or propeller type mixer shall be specified if the downstream unit can be upset by the feed which is not consistent in quality.

9.6.2 The number and location of mixer connections shall be determined by the Design Engineer and specified on the tank data sheet.

9.6.3 Mixer nozzle connections shall not be used for regular access manways.

9.6.4 Low liquid level switches shall be positioned such that the mixer motor will stop when the liquid level is 75 mm (3 inch) above the top of the propellers.

9.6.5 Propeller-type mixers shall be specified in accordance with 32-SAMSS-017.

9.6.6 Jet-nozzle mixers shall not be used in tanks with internal floating roofs.

9.7 Temperature Instruments

9.7.1 Dial thermometers shall be specified on all tanks when other types of temperature instruments are not provided. The thermometers shall be located in the vicinity of the tank outlet nozzle and 0.3 m (12 inch) above the tank base line. The sensing point shall be 1 m (39 inch) inside the tank shell and located such that it will not be affected by the tank heater, where specified.

9.7.2 Tanks with heaters shall be equipped with a self-actuating temperature controller, unless the inlet steam temperature is such that the condensing temperature will not exceed the process needs. The location of the

sensing point for the controller shall be the same as for a dial thermometer.

9.7.3 Permanently installed, multiple spot temperature elements shall be used whenever the functional specification requires automatic computation of Gross Standard Volume (GSV) or Net Standard Volume (NSV). Design requirements for the elements shall be according to SAES-J-300.

9.8 Level Gauging Systems

9.8.1 Level gauging systems shall be specified in accordance with SAES-J-300.

9.8.2 A minimum of one level gauging instrument per tank, readable from grade, shall be specified.

9.8.3 External floating roof tanks shall be provided with a radar gage assembly in accordance with SASD AA-036256.

9.8.4 Provisions for manual gauging shall be specified for all atmospheric tanks, in addition to the automatic gauging devices.

9.9 Sample Connections

9.9.1 Sample connections shall be specified by the operating unit at the facility.

9.9.2 The number, size and location of sample connections shall be shown on Saudi Aramco Form 2696-ENG.

9.10 Water Draw-off Connections

9.10.1 The Design Engineer shall specify the number of water draw-off connections in consultation with the operating unit based on operational requirements. For tanks in hydrocarbon service, a minimum of one water draw-off connection shall be provided.

9.10.2 Sumps in accordance with API STD 650 and SAES-B-057 shall be specified for water draw off connections.

9.11 Cleanout Fittings

9.11.1 A flush-type cleanout fitting shall be specified for tanks in dirty service, such as crude tanks.

9.11.2 The cleanout fitting size shall be 914 mm x 1219 mm (36 inch x 48 inch) minimum.

9.12 Foam and Firewater Systems

The requirements for foam and fire water systems shall be specified in accordance with SAES-B-017 and SAES-B-018.

9.13 Stairways, Ladders and Platforms

9.13.1 Stairways, ladders and platforms shall be specified in accordance with SAES-B-054.

9.13.2 A spiral stairway shall be specified for external floating roof tanks. A top platform with a guard railing shall be specified for access from the top of this stairway to the gauge well and the rolling ladder.

9.13.3 A spiral stairway shall be specified for fixed roof tanks over 6 m (~20 ft.) in height and for tanks requiring gauging or sampling from the roof. A platform shall also be specified for access to the gauge or sampling hatch.

9.13.4 A vertical ladder shall be specified for tanks that do not require spiral stairways.

9.13.5 Stairs shall be located on the upwind side with respect to the prevailing wind direction of the tank. This arrangement shall be shown on Saudi Aramco Form 2696-ENG.

9.14 Roof drain

External floating roofs shall be provided with primary drains of either the flexible pipe (Coflexip or equal), or the articulated pipe type. A swing type check valve shall be provided at the inlet of the drain. Siphon type drains are not acceptable for primary roof drains. Siphon type drains, however, may be provided as a secondary roof drain if specified on the Storage Tank Data Sheet. Emergency drains for double deck floating roofs shall be of the open-type design.

10 Painting and Coatings

10.1 Surface preparation, painting, and coating specifications shall be selected in accordance with SAES-H-001.

10.2 The Design Engineer shall specify all painting requirements on the tank data sheet in accordance with SAES-H-101, including the Approved Protective Coating Systems (APCS), surface preparation, and primer type, number of coats, total thickness and the areas or parts of the tank to be painted.

11 Insulation

11.1 The Design Engineer shall specify the type and thickness of external insulation in accordance with SAES-N-001, where required.

11.2 Insulation materials shall be noncombustible or have a flame spread index of 25 or less established per NFPA 255.

12 Lighting

The Design Engineer shall specify the lighting requirements in accordance with SAES-P-123.

13 Grounding

The Design Engineer shall specify the grounding requirements in accordance with SAES-P-111, SASD AD-036387, and API RP 2003 for tanks in hydrocarbon service.

14 Cathodic Protection

14.1 Cathodic protection requirements shall be in accordance with SAES-X-500 and SAES-X-600.

14.2 The Design Engineer shall specify cathodic protection system design details that are required to protect tank internals and the underside of the bottom from corrosion. The Design Engineer shall also provide appropriate calculations that verify the proposed design.

15 Foundations

15.1 Spacing and diking of tanks shall be in accordance with SAES-B-005.

15.2 The Design Engineer shall provide the Tank Manufacturer with a foundation drawing showing all dimensions and tolerances in accordance with SAES-Q-005.

15.3 Design of foundations for refrigerated storage tanks shall consider thermal movement of the tank, the insulation required for the bottom, the effects of foundation freezing and possible frost heaving, and the anchorage required to resist uplift according to API STD 620 and API STD 2510.

15.4 Refrigerated storage tanks shall provided with spill containment facilities according to API STD 2510 and API PUBL 2510A.

16 Under Tank Leak Detection and Sub-Grade Protection

16.1 Tanks in services other than water shall be provided with an under tank leak detection and sub-grade protection according to API STD 650, Appendix I. Acceptable construction details are Figures I-1, I-2, I-3, I-8, I-9 and I-10.

16.2 Flexible membrane liner of minimum 1000 microns (40 mils) thickness compatible with the stored product shall be specified under the tank bottom. The liner shall be placed according to SASD AA-036355, extending to the internal top edge of the ring foundation.

16.3 Joints in the liner shall satisfy the leak tightness, permeability, and chemical resistance requirements for the liner material.

16.4 Alternative under-tank leak detection and sub-grade protection systems shall not be permitted without the prior approval of the Saudi Aramco Engineer.

17 Drawings, Calculations and Data

17.1 The Design Engineer shall complete the tank data sheet and forms to the extent specified in this standard.

17.2 The Design Engineer is responsible for completion of the Tank Safety Instruction Sheet (Saudi Aramco Form 2694-ENG) in accordance with the data provided by the Tank Manufacturer and SAES-A-005.

Revision Summary

31 December, 2003 Major revision.

Appendix G – Structurally Supported Aluminum Dome Roofs

G.5 Roof Attachment

G.5.3 Separation of carbon Steel and Aluminum

(Exception) Aluminum shall be isolated from carbon steel by austenitic stainless steel spacers.

G.5.5 The dome surface paneling shall be designed as a watertight system under all design load and temperature conditions. All edges of aluminum panels shall be covered, sealed, and firmly clamped with batten in an interlocking manner to prevent slipping or disengagement under all load and temperature conditions.

G.8 Roof Vents

G.8.4.3 Surface appurtenances and closure panel joints shall be designed watertight without the use of sealants.

Appendix L – Completion of API STD 650, Storage Tank Data Sheet

The Design Engineer shall complete the following portions of the tank data sheet:

1. Page 1 of Data Sheet

    1) All items on Page 1.

    2) Item 5, the maximum pumping rates must be specified in order to properly size the vents.

    3) Nozzle loads from connected piping on shell nozzles for tanks larger than 36 m (118 ft) in diameter and nozzles 152 mm (6 inch) NPS and greater.

2. Page 2 of Data Sheet

    1) Item 6, tank bottom slope in accordance with paragraph 8.8 of this standard.

    2) Item 8, roof-to-shell details: API STD 650, Figure F-2: (d), (e), (g), (h), or (i).

    3) Item 10, roof type in accordance with paragraphs 6 and 8.7 of this standard.

    4) Item 12, paint in accordance with Paragraph 10 of this standard.

    5) Item 13, tank bottom coating.

    6) Item 18, mill test reports are required.

    7) Item 19, applicable Saudi Aramco Standard Drawings and Forms shall be listed.

    8) Item 21, 32-SAMSS-005 and other applicable SAMSSs shall also be listed.

3. Page 3 of Data Sheet

    1) Item 1, stairway style in accordance with paragraph 9.13 of this standard.

    2) Item 3, Draw off sump in accordance with paragraph 9.10 of this standard.

    3) Item 4, cleanout fitting in accordance with paragraph 9.11 of this standard.

    4) Item 6, internal piping in accordance with paragraphs 9.4.

    5) Item 7, siphon roof drains are not acceptable as primary drains. They may be specified as secondary roof drains.

6) Items 8, 9, 10 and 11, number and size of shell and roof manholes, and shell and roof nozzles, in accordance with completed Saudi Aramco Form 2696-ENG for the tank.

7) Other accessories, such as level gages, foam systems, grounding lugs, etc., which are to be supplied by the Tank Manufacturer, shall also be included on the tank data sheet.