Engineering Standard

SAES-P-111 25 December 2012

Grounding

Document Responsibility: Electrical Systems Designs and Automation Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This standard prescribes the mandatory requirements for design and installation of grounding systems and lightning protection systems for Saudi Aramco facilities.

2 Conflicts, Deviations and Commentary

2.1 Any conflicts between this Standard and other Mandatory Saudi Aramco Engineering Requirements (MSAERs*) or referenced industry standards shall be identified to the Company or Buyer Representative who will request the Manager, Consulting Services Department of Saudi Aramco, Dhahran to resolve the conflict.

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 Waiver Request to the Manager, Consulting Services Department of Saudi Aramco, Dhahran requesting his approval.

2.3 The designation "Commentary" is used to label a sub-paragraph that contains comments that are explanatory or advisory. These comments are not mandatory, except to the extent that they explain mandatory requirements contained in this SAES.

3 References

The selection of material and equipment, and the design, construction, maintenance, and repair 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 Standards

SAES-A-112	*Meteorological and Seismic Design Data*
SAES-B-070	*Bulk Plants*
SAES-J-902	*Electrical Systems for Instrumentation*
SAES-M-006	*Saudi Aramco Security and General Purpose Fencing*

SAES-P-100	*Basic Power System Design Criteria*
SAES-P-104	*Wiring Methods and Materials*
SAES-P-107	*Overhead Distribution Systems*
SAES-T Series	*Communications Engineering Standards*
SAES-X-400	*Cathodic Protection of Buried Pipelines*

Saudi Aramco Materials System Specification

15-SAMSS-502	*Medium Voltage Power Cables 5 kV though 35 kV*

Saudi Aramco Library Drawing

DD-950022	*Grounding Connections Details Ground Rod to Ground Grid*

Saudi Aramco Standard Drawings

AB-036387	*Tank Grounding*
AA-036572	*Grounding Arrangement for Disconnect Switch Structure*

Saudi Aramco Engineering Report

SAER-1838	*Insulation Coordination*

3.2 Industry Codes and Standards

American National Standards Institute

ANSI C2	*National Electrical Safety Code*

American Petroleum Institute

API RP 2003	*Protection against Ignitions Arising out of Static, Lightning, and Stray Currents*

Institute of Electrical and Electronics Engineers

IEEE 80	*Guide for Safety in Alternating-Current Substation Grounding*
IEEE 81	*Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System*
IEEE 142	*Recommended Practice for Grounding of Industrial and Commercial Power Systems*

IEEE 399	*IEEE Recommended Practice for Power Systems Analysis (Brown Book)*
IEEE 1100	*Powering and Grounding Sensitive Electronic Equipment*

International Electrotechnical Commission

62305-1	*Protection against Lightning - Part 1*
62305-2	*Protection against Lightning - Part 2*
62305-3	*Protection against Lightning - Part 3*
62305-4	*Protection against Lightning - Part 4*
IEC 61024-1-1	*Protection of Structures against Lightning Part 1: General Principles Section 1: Guide A - Selection of Protection Levels for Lightning Protection Systems*

National Fire Protection Association

NFPA 70	*National Electrical Code*
NFPA 99	*Health Care Facilities*
NFPA 780	*Lightning Protection Code*

Underwriters Laboratories

UL 96	*Lightning Protection Components*
UL 96A	*Installation Requirements for Lightning Protection Systems*
UL 467	*Grounding and Bonding Equipment*

4 General

4.1 For 1 kV nominal voltage and below, grounding and ground systems shall be in accordance with the IEEE 142 and meet the requirements of ANSI/NFPA 70 (NEC), and ANSI C2, as supplemented or amended by this Standard. This includes:

a) Residential facilities.

b) Recreational facilities.

c) Schools.

d) Office buildings (including those associated with plants and industrial facilities).

e) Swimming pools and fountains including equipotential bonding requirements stated in the Saudi Building Code and/or NEC article 680.

4.2 For substations having equipment operating at a nominal system voltage exceeding 1 kV, a ground grid meeting the requirements of IEEE 80 for step and touch potential shall be installed.

4.3 Supplementary Grounding electrodes shall be used where bonding is needed to ensure equipotential, per Section 9.

4.4 Grounding and ground system requirements for specific facilities are as follows:

a) Health Care Facility grounding shall meet additional requirements of NFPA 99;

b) Communications System grounding shall be in accordance with the SAES-T Series;

c) SAES-J-902 shall take precedence over this standard for grounding of process control instrumentation and process control systems. Refer to SAES-J-902 for grounding sensitive electronic equipment associated with process control systems.

Commentary Notes 4.4:

It is intended that the terminology used in this standard be consistent with the NEC.

Sensitive electronic equipment not covered by SAES-J-902 should be grounded in accordance with the recommendations of IEEE 1100.

4.5 Measurements of earth resistivity and ground impedance shall be made in accordance with IEEE 81 or by a non-contacting ground resistivity mapping instrument. In soils exceeding 5000 ohm-cm. the measurements shall be taken or verified by a non-contacting ground resistivity-mapping instrument.

Commentary Note 4.5:

Special techniques may be needed to avoid errors in measuring earth resistivity in areas congested with existing grounding systems, existing cathodic protection systems, and/or existing underground metal structures.

5 Materials and Installation

This section applies to electrical installations in industrial facilities, residential areas, recreational facilities and office buildings.

5.1 Conductors used as grid conductors, grounding electrode conductors, equipment ground conductors, or bonding conductors in grounding systems shall:

a) Be soft or annealed copper.

b) Be insulated; PVC jacketed.

Exception:

Grid conductors and grounding electrode conductors used for substation grids shall not be insulated.

c) If larger than 35 mm² (#2 AWG) be stranded. Stranding of ground conductors shall comply with the stranding requirements of SAES-P-104.

d) If insulated, shall have a green jacket or a green jacket with yellow stripes.

Exception 5.1.d:

Grounding conductors used for isolated ground equipment, installed per IEEE 1100, must be labeled or color coded to distinguish them from standard equipment grounding conductors.

5.2 Ground rods shall have the following characteristics:

a) Be copper or copper jacketed steel or galvanized steel. Copper jacketed steel shall meet the requirements of UL 467.

b) If galvanized steel, be only used in areas protected by cathodic protection.

c) Have a minimum length of 2.4 meters. Jointed rods are permitted but each joint must be at least 2.4 meters long.

d) If copper or copper jacketed steel rods, be a minimum of 16 mm in diameter, and if galvanized steel rods be a minimum of 19 mm in diameter.

e) When grounding is required at pipeline valve stations, zinc or magnesium anodes interconnected with insulated copper cable may be used in lieu of copper clad or galvanized steel ground rods. Each ground rod shall be replaced with a zinc or magnesium anode. A minimum of two zinc or magnesium anodes spaced a minimum of 2 meters apart shall be installed. Installation of the anodes shall be in accordance with SAES-X-400.

Commentary Note 5.2:

Soils in Saudi Aramco areas which are lower than 70 ohm-meters resistivity normally have high salt content and are corrosive to copper. In areas where cathodic protection is present, galvanized steel ground rods are recommended. Buried bare copper has a detrimental effect on pipeline cathodic protection.

5.3 Below ground connections to grounding grids and ground rods, or between conductors and/or grounding rods, shall be made using one of the following methods:

a) By thermite welding or brazing.

b) By irreversible compression-type connectors listed as grounding and bonding equipment, and have a manufacturer's reference compression die number and conductor size printed or stamped on the connector.

c) By mechanical connectors where it is necessary to disconnect ground conductors for tests at ground test stations.

Commentary Note 5.3:

Library Drawing DD-950022 shows recommended details for making grounding connections.

5.4 Above ground grounding system connections shall be made by one of the following:

a) In accordance with the NEC as supplemented by SAES-P-104.

b) By thermite welding or brazing.

c) To structural steel, by compression type connectors bolted to bare steel.

5.5 Bare grounding conductors shall not be installed in metallic conduit.

5.6 Grounding conductors extending through concrete or asphalt shall be run in PVC conduit (preferred) or PVC coated rigid steel conduit.

5.7 Underground ground conductors shall be insulated when within 3 meters of a buried metal pipeline or metal piping.

6 Substation Grounding

6.1 Per Section 4, the design for the substation grid and the associated overall plant grounding system shall account for hazards due to transferred potentials caused by a fault in the substation. All electrical equipment in the substation, substation yard, and within 5 meters of the substation fence shall be connected to the grid or to a ground bus connected to the grid.

Commentary Note 6.1:

See IEEE 80 For Discussion of Transferred Potentials.

6.2 The design package for ground grids and systems for substations with equipment operating at above 15 kV shall be submitted to the Coordinator, Electrical Systems Division, Consulting Services Department for review.

6.3 Substation ground grids shall be constructed of minimum 70 mm² (2/0 AWG) stranded bare copper conductor, and if used in soils less than 70 ohm-meters

resistivity shall be tinned.

6.4 Calculations of allowable and actual step and touch potentials shall be done in accordance with IEEE 80 using the following parameters:

6.4.1 A body weight of 50 kg shall be assumed.

6.4.2 Duration of ground faults used in calculations for maximum allowable step and touch potential shall be the time (based on known operating conditions) it would take for the breaker backup protection to clear the fault and shall not exceed 0.5 sec.**).**

6.4.3 Ground fault current shall be the higher of the line to line to ground or the symmetrical line to ground fault current.

6.4.4 In calculations of the grid current, the current division factor shall be 1.0 unless site conditions are provided to justify a lower number.

Commentary Note 6.4.4:

The current division factor is used to account for the current that returns to the source though an overhead ground wire rather than through the substation ground grid and earth.

6.4.5 For calculations of allowable step and touch potentials, the resistivity of the surface material (rho sub s) shall be assumed to be 3,000 ohm-meters for a minimum 75 mm thick pad of clean crushed rock, 10,000 ohm-meters for a minimum 50 mm layer of asphalt, and 200 ohm-meters for a minimum 75 mm layer of concrete. For all other surface materials, the lower of 100 ohm-meters or the actual measured top layer (minimum 0.3 m layer thickness) soil resistivity shall be used.

6.4.6 Calculations of mesh voltage and ground potential rise shall be based on actual measured soil resistivity. Soil resistivity of backfill material used for ground grids and ground rods shall be the same as or less than that of the surrounding soil.

6.5 Commissioning tests shall be performed to verify that resistance to remote earth of substation ground grids and/or ground electrodes used for system grounding meet design requirements.

6.6 New ground grids shall be provided with test stations (wells) to facilitate future tests. Test wells shall be reasonably distributed to cover the entire grid evenly.

7 Grounding Electrodes

7.1 Grounding electrode systems for residential areas, recreational facilities, schools, and office buildings, shall be in accordance with the NEC with the following additions/exceptions:

7.1.1 Reinforcing bar of buildings shall not be used as a grounding electrode. Structural steel of a building may be used as a grounding electrode in accordance with the NEC provided it is continuous and effectively grounded by connecting at least every other structural steel column on the perimeter of the building to a concrete-encased electrode or a ground ring installed per the NEC and this standard.

7.1.2 If a concrete-encased electrode is used, the conductor must be bare copper.

7.1.3 The ground electrode for system grounding shall consist of either (1) rod or pipe electrode(s), or (2) a combination of rod or pipe electrodes and a grid or loop of bare copper conductors buried a minimum of 460 mm. Multiple rod or pipe electrodes shall be interconnected by bare or insulated copper conductors using thermite welding or approved connectors per Section 5. Conductors used to interconnect rod or pipe electrodes shall be buried a minimum of 460 mm.

Commentary Note 7.1.3:

Minimum conductor burial depth and length requirements of the NEC are applicable for "Ground Rings" encircling a building or structure that constitutes the only made electrode for the building. Minimum burial depth requirements of this paragraph apply to conductors used to interconnect rods or other made electrodes.

7.2 When required, supplementary grounding electrodes per NEC 250-54 shall be provided in outdoor industrial areas, process plant areas, and in substations not covered by Section 6. Resistance to ground of each supplementary grounding electrode system shall meet the minimum requirements of NEC Article 250-56 for made electrodes.

7.3 If an above ground bus or loop is used for extending the supplementary grounding electrodes, this bus or loop shall have two connections.

7.4 Conductors used for interconnection of ground rods shall be minimum of 70 mm^2 (2/0 AWG).

8 System Grounding

8.1 Three-phase electrical systems shall be grounded in accordance with Table 1 of SAES-P-100. The system grounding connections shall be made directly to the grounding electrode and be routed separately from equipment grounding connections.

Exceptions:

Systems fed from a transformer with a primary voltage less than 600 V shall be grounded in accordance with NEC rules for separately derived systems.

Dry-type lighting or building service transformers in substations, in switchgear rooms, or in equipment rooms may be connected to a ground bus that is directly connected to the grid or other grounding electrode.

8.2 Solidly grounded systems below 1 kV

8.2.1 The ground resistance of made electrodes (ground rods and/or ground grid) used for system grounding shall not exceed 5 ohm.

8.2.2 Neutral conductor shall be selected based on 3 seconds fault duration.

8.3 Impedance grounded systems above 1 kV

8.3.1 The ground resistance of made electrodes (ground rods and/or ground grid) used for system grounding shall not exceed 5 ohm.

8.3.2 For industrial facilities, grounding impedance shall be 400 A, 10 Second Resistor.

8.3.3 For commercial facilities and residential areas, grounding impedance shall be 1000 A, 10 Second Resistor.

8.3.4 Neutral conductor shall be selected based on 10 seconds fault duration.

8.4 Solidly grounded systems above 1 kV

8.4.1 The ground resistance of made electrodes (ground rods and/or ground grid) used for system grounding shall not exceed 1 ohm.

8.4.2 Neutral conductor shall be selected based on 3 seconds fault duration.

8.5 Generator Neutral Grounding per 17-SAMSS-510

8.5.1 Generator neutral grounding system for large direct-connected units shall be low resistance type as defined by IEEE C37.101, Table 1, Method III (Low resistance).

8.5.2 The neutral ground for large unit-transformer connected generators shall be high resistance type as defined by IEEE C37.101, Table 1, Method I (Distribution Transformer Grounded-High resistance).

8.5.3 Medium size direct connected generators shall be low resistance type as defined by IEEE C37.101, Table 1, Method III (Low resistance).

8.5.4 Neutral conductor shall be selected based on 10 seconds fault duration.

8.6 All grounding electrodes used for system grounding in plants, bulk distribution facilities, or other industrial areas shall be interconnected to form a single ground system. The grounding electrode used for system grounding (including separately derived systems) for each area in the facility or plant shall have a minimum of two connections to the ground grid or ground loop used in the area. This requirement can be met by connections to the grounding electrode of the substation(s) which supply the area.

8.7 The secondary of dedicated (captive) transformers supplying electric submersible pumps in water or oil well service are permitted to be ungrounded provided that the motor controller has ground fault detection and the transformer is located at the same well site as the pump served.

Commentary Note:

Ungrounded supply from captive transformers for electric submersible pumps is recommended.

9 Equipment Grounding

9.1 Equipment grounding conductor shall be provided with each power circuit. Except as otherwise noted below, conduit, cable tray, or cable armor, shall not be relied on as the equipment grounding conductor. An insulated copper conductor shall be installed in the same conduit, cable tray, cable, or cord or shall otherwise accompany the power conductors.

Exceptions 9.1:

Conduit or cable armor may be used in accordance with the NEC for grounding electronic instrumentation operating at 24 V DC nominal or below.

Cable armor, if properly sized and terminated with cable terminators that are approved for grounding purposes may be used for equipment grounding in accordance with the NEC (cable armor must be a type that is specifically permitted by the NEC for such use) provided the cable runs in one continuous length (no splices or intervening junction boxes are permitted) from the substation or equipment controller to the equipment being grounded and the cable is not in direct contact with the soil for any portion of the run. Repairs to existing cable

meeting the requirements are permitted provided armor of the two sections is properly bonded.

Aluminum cable trays containing only circuits operated at, or below, 50 V to ground may be used as equipment grounding conductors provided that NEC requirements for such use are met.

Commentary Note 9.1:

In accordance with the NEC an equipment grounding conductor is not required between the neutral point of a transformer and a service disconnecting means. The grounded circuit conductor (neutral) required by the NEC is sufficient. See NEC Article 250.

9.2 Regardless of whether this standard permits conduit, cable tray or cable armor, to be relied on as the equipment grounding conductor, the conduit, cable tray, or cable armor installations must meet NEC bonding and grounding requirements for such use.

9.3 In hazardous locations, equipment grounding conductors run in conduit or cable tray shall be insulated or enclosed within the jacket of a multi-conductor cable.

9.4 On aluminum cable trays, a common equipment grounding conductor external to the cables in the tray may be used under the following conditions:

- This common conductor shall be sized in accordance with NEC Table 250-66 for the largest power conductor in the tray, with a minimum size of 25 mm² (#4 AWG).
- Connections shall be made between this common grounding conductor and other grounding conductors for intersecting or branch trays, and to extend the equipment grounding conductor beyond the tray.
- This common conductor (or the largest individual grounding conductor, if more than one are installed) shall be bonded to each section of the cable tray system with a connector approved for a copper to aluminum connection.

9.5 A cable concentric neutral, if properly sized and not used as a current carrying grounded circuit conductor (3 phase 3 wire system; no neutral loads are served), may be used as the equipment grounding conductor.

Commentary Note 9.5:

The cable must meet the requirements of 15-SAMSS-502 that requires an overall jacket to protect the concentric neutral.

9.6 Electrical submersible pump motors in oil and water well service do not require a dedicated equipment grounding conductor, provided the motor controller has

ground fault detection. The well head must be bonded by an approved means to the ground bus at the motor controller or supply transformer.

9.7 Armored submarine cables do not require equipment grounding conductors.

9.8 Shields and armor of power cable shall be grounded at both ends. Continuity at splices shall be maintained by bonding across the splice. For circuits with single core conductors, circulating currents and associated potential rise shall be minimized. Cables shields, sheaths, joints, braided leads, and grounding bonds shall be rated for the maximum currents including motor acceleration periods.

9.9 Metallic conduit shall be grounded at both end points by bonding to a grounding conductor, a grounded metal enclosure, or to a grounded metal cable tray. This may be accomplished:

- with listed or marked grounding clamps and conductors connected externally to the conduit.
- by bonding to a grounded enclosure using integral threaded bushings or using a conduit hub which is listed or marked for grounding purposes.
- bonding to a grounding conductor using listed or marked grounding bushing. Grounding with locknuts is not acceptable.
- where non-PVC coated rigid conduit is used to protect cable entering or exiting a grounded metal cable tray, by bonding with a conduit clamp to the cable tray. A grounding bushing must be used with PVC coated conduit.

Exceptions 9.9:

Where EMT is permitted it may be grounded and bonded in accordance with the NEC.

Isolated sections of rigid metal conduit that are buried at all points at least 0.5 meters below grade are not required to be grounded. (e.g., Conduit sleeves for road crossings.)

Conduit sleeves used to enclose power cables transitioning from above grade to below grade are required to be grounded only at the above grade end.

9.10 Metallic cable trays shall be bonded to the local ground grid or ground electrode at both end points ensuring that bonding continuity is met throughout all the racks in the system.

9.11 Ground busses in switchgear, switchboards, and motor control centers shall have two connections to the local ground grid or the main ground electrode.

9.12 Electrical manholes shall be grounded using two ground rods located close to diagonally opposite corners of the manhole. These rods shall be connected to each other, to a ground loop or bus accessible from inside the manhole, and, where applicable, to a minimum 120 mm² (4/0 AWG) grounding conductor that is connected to the local (within 15 m) grounding grid.

9.13 Raised computer floors shall be grounded by bonding a minimum of two pedestals at opposite corners to the nearest ground bus or grounding electrode. Refer to IEEE 1100 for guidance on grounding of raised floors used with sensitive electronic equipment.

9.14 The following equipment shall be connected to the local ground grid, grounding electrodes, or supplementary grounding electrodes described in Section 7. This is in addition to equipment grounding conductors running with the power conductors that are required by the NEC and this standard.

Exception 9.14:

See Section 10 for supplementary grounding on offshore platforms.

9.14.1 Structural steel supports for process equipment and piping and structural steel columns for buildings. Connections shall be made at least every 25 m (i.e., No part of the base of the structure shall be more than 25 m from a grounded support or column.) with a minimum of two connections at opposite corners of each structure or building.

9.14.2 Frames of equipment (motors, generators and transformers) operating at 1000 V or greater shall have two connections to the grounding electrode.

9.14.3 Motors, transformers, and generators operating at a nominal voltage of 480 V shall have a minimum of one connection to the grounding electrode.

9.14.4 Motor Operated Valves (MOV), lower voltage motors and transformers are grounded through the associated EGC (equipment grounding conductor).

9.14.5 The following equipment when not bolted to grounded structural steel shall be connected to a supplementary grounding electrode:

9.14.5.1 Metallic enclosures for panelboards, circuit breakers, switches, fuses, motor controllers, switchgear, switchracks, motor control centers, and motors and transformers not covered above.

9.14.5.2 Metal vessels, stacks, exchangers and similar equipment.

9.14.5.3 Loading and unloading facilities.

9.15 Manually operated switches for overhead power lines shall have operating platforms and be grounded as shown on Standard Drawing AA-036572.

9.16 Minimum conductor size used for connection of equipment to ground rods or ground grid shall be 25 mm² (#4 AWG).

Exception 9.16:

See SAES-P-107 for pole ground wires.

10 Offshore Platform Grounding

10.1 The main ground electrode for the platform shall consist of a copper cable or copper bar minimum size 120 mm² (4/0 AWG) which is connected to two platform legs. In addition, the main ground electrode shall be connected to the structural steel in a minimum of two locations at opposite sides of the main substation area. Connections to the platform legs, structural steel and any splices in this main ground electrode shall be made by exothermic welding or brazing. System grounding connections shall be made directly to this ground electrode.

10.2 Tanks of medium and high voltage transformers and ground busses for switchgear and motor control centers shall have two paths for current to flow to this ground electrode. The main ground electrode is not required on platforms that do not have transformers or generators which require system grounding connections.

10.3 Where two or more platforms which require main ground electrodes are connected by walkways, two insulated conductors, minimum size 120 mm² (4/0 AWG) shall be installed between the respective main ground electrodes.

10.4 Equipment grounding shall be done per Section 9 of this standard except that required local supplementary grounding of motors, low voltage transformers, etc. which are not in the main substation area may be done by using a bonding jumper that is connected to structural steel or deck plate by brazing or exothermic welding or connection to a copper ground bus that is connected to structural steel or deck plate by brazing or exothermic welding.

10.5 Exposed grounding conductors shall be insulated. Insulation shall be green, or green with yellow stripes. Exposed connections and terminations shall be thoroughly covered with a suitable weather resistant compound for protection from corrosion.

11 Fence Grounding

11.1 Electrical substation fences shall be grounded as follows:

11.1.1 Substation fences shall not be PVC coated and shall be grounded in a minimum of two locations to the local ground grid or loop.

11.1.2 All fences (including grillwork and gates used to control access to the area under the substation) for substations containing equipment fed from solidly grounded systems operating at above 1000 V line to line shall be bonded to a grounding conductor buried approximately 1 m outside the fence and parallel to the fence. A second conductor shall be buried 1 m inside the fence if the substation ground grid does not extend into this area. The grounding conductor(s) shall be connected to the substation ground grid at a minimum of four locations spaced equally around the loop. The fence shall be connected to the grounding conductor(s) at intervals not exceeding 15 m. Corner posts and gateposts shall be connected to the grounding conductor. Gates shall be bonded to the gateposts with flexible connectors. Grillwork and gates used to control access to the area under the substation shall meet the bonding and grounding requirements for substation fencing.

11.2 Non-substation fences shall be grounded as follows:

11.2.1 Fences which are within 10 m of an enclosed ground grid or ground loop that is connected to equipment operated at 1000 V or greater shall not be PVC coated and shall be grounded at intervals not exceeding 15 m to the ground grid or loop.

11.2.2 All fences within 3 meters of a ground grid or ground electrode shall be bonded at the nearest fence post to the ground grid or ground electrode.

11.2.3 Fences that pass under a transmission line operating at 34.5 kV and above shall not be PVC coated and be grounded at intervals not exceeding 15 m per 11.2.1 on that portion of the fence within 100 m of the power line.

11.2.4 Fences that cross over a ground grid, or conductors that connect two ground grids, shall not be PVC coated and shall have a bond between the grid or conductors and the nearest post. If the crossing area is extensive, the bond is required every 50 m.

Exception 11.2.4:

If the ground conductors used to connect the ground grids are insulated

and sleeved with PVC conduit at points within 10 m of the fence, then the bond is not required.

11.3 Fences constructed with concrete posts and PVC coated fencing material are not required to be grounded.

Commentary Note 11.3:

See SAES-M-006 for fence requirements.

11.4 Fences not required to be grounded by this standard shall not be grounded.

12 Tank Grounding

12.1 The shells of onshore storage tanks in hydrocarbon service shall be grounded at a minimum of two points on diagonally opposite sides of the tank. Each point shall be bonded to the area ground grid or to a minimum 16 mm x 2.4 m ground rod. The tank shell to remote earth resistance shall not exceed 10 ohms.

12.2 Floating roof tanks shall have stainless steel shunts between the tank roof and the metal sealing ring. These shunts shall be spaced a maximum of 3 m apart, shall be above the seal, and shall be bolted to the sealing ring and the roof per Standard Drawing AB-036387. On tanks with primary and secondary seals, the shunt shall be above the secondary seal. (i.e., No shunt between the seals.)

13 Lightning Protection

13.1 Lightning protection system design and installation shall be based on:

- NFPA 780, UL 96A, and IEEE 998.
- or IEC 62305-1,2,3,4.

13.2 The following Facilities shall be provided with a lightning protection system:

13.2.1 Buildings and occupied structures over 30 m in height;

13.2.2 Schools;

13.2.3 Hospitals;

13.2.4 High Voltage outdoor substations and switchyards if the area is 3250 m² or greater.

13.2.5 Petroleum facilities.

13.2.6 If required by NFPA 780.

The following shall be used as the basis for the NFPA 780 calculations:

a) Isokeraunic level (I) shall be the greater of the value listed in SAES-A-112, or a level of 10.

b) "Annual Ground Flash Density" (Ng) shall be calculated using the formula Ng=0.00282xIxI (annual ground strikes per square kilometer).

Commentary Note:

Formula and substation area is from Saudi Aramco Engineering Report SAER-1838.

13.3 Lightning protection components shall be UL Listed or Labeled in accordance with UL 96 for lightning protection service or equivalent certification approved by ESD Coordinator.

13.4 Lightning protection system design and installation of Petroleum facilities shall comply with API RP 2003.

14 Static Electricity Grounding

Tank trucks, tank cars, tanks, other large containers, associated filling apparatus, and other equipment which during normal operation can cause accumulation of sufficient static charge to cause an ignition of hydrocarbon vapors in the area shall be bonded and grounded in accordance with API RP 2003. Also, see SAES-B-070 for requirements for control of static electricity at bulk plants.

Revision Summary

25 December 2012 Major revision.