

Engineering Standard

SAES-P-111

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Grounding

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Saudi Aramco DeskTop Standards

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1 Scope

This standard prescribes minimum mandatory requirements for design and installation of grounding systems and lightning protection systems for Saudi Aramco facilities. This document may not be attached to nor made a part of purchase orders.

2 Conflicts, Deviations, and Commentary

- 2.1 If there are any conflicts between this Standard and associated purchasing, project or engineering documents, this standard shall take precedence. The exception is if an approved Waiver form SA 6409-ENG has been included with the purchasing documents.
- 2.2 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.
- 2.3 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.
- 2.4 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-B-070](#)

Bulk Plants

<u>SAES-M-006</u>	<i>Saudi Aramco Security and General Purpose Fencing</i>
<u>SAES-J-902</u>	<i>Electrical Systems for Instrumentation</i>
<u>SAES-P-100</u>	<i>Basic Power System Design Criteria</i>
<u>SAES-P-104</u>	<i>Wiring Methods and Materials</i>
<u>SAES-P-107</u>	<i>Overhead Distribution Systems</i>
<i>SAES-T Series</i>	<i>Communications Engineering Standards</i>
<u>SAES-X-400</u>	<i>Cathodic Protection of Buried Pipelines</i>

Saudi Aramco Materials System Specification

<u>15-SAMSS-502</u>	<i>Medium Voltage Power Cables 5 kV through 35 kV</i>
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Saudi Aramco Library Drawing

<i>DD-950022</i>	<i>Grounding Connections Details Ground Rod to Ground Grid</i>
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Saudi Aramco Standard Drawings

<u>AB-036387</u>	<i>Tank Grounding</i>
<u>AA-036572</u>	<i>Grounding Arrangement for Disconnect Switch Structure</i>

3.2 Industry Codes and Standards

American National Standards Institute

<i>ANSI C2</i>	<i>National Electrical Safety Code</i>
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American Petroleum Institute

<i>API RP 2003</i>	<i>Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents</i>
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Institute of Electrical and Electronics Engineers

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

IEEE 399 *IEEE Recommended Practice for Power Systems Analysis (Brown Book)*

IEEE 1100 *Powering and Grounding Sensitive Electronic Equipment*

International Electrotechnical Commission

IEC 61662 *Assessment of Risk of Damage Due to Lightning*

IEC 61024-1 *Protection of Structures Against Lightning*

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 Except as noted in 4.2, grounding and ground system installation shall be designed in accordance with IEEE 142 and meet the requirements of ANSI/NFPA 70 (NEC), and ANSI C2, as supplemented or amended by this Standard. 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.
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Commentary Notes 4.1:

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.

- 4.2 Except as specifically noted, electrical installations in residential facilities, recreational facilities, schools and office buildings (including office buildings associated with plants and industrial facilities) shall be grounded in accordance with the industry standards referenced in 4.1 and are not required to meet the additional requirements contained in this standard.
- 4.3 Measurements of earth resistivity and ground impedance shall be made in accordance with IEEE 81 or by a non-contacting ground resistivity mapping instrument (Geonics or equal). In soils exceeding 5000 ohm-cm. the measurements shall be taken or verified by a non-contacting ground resistivity-mapping instrument.

Commentary Note 4.3:

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.

- 4.4 Calculations of allowable and actual step and touch potentials shall be done in accordance with IEEE 80 using the following parameters:
- 4.4.1 A body weight of 50 kg shall be assumed.
- 4.4.2 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 backup breaker to clear the fault with a minimum of 0.25 sec. and a maximum of 1.0 sec.
- 4.4.3 Ground fault current shall be the higher of the line to line to ground or the symmetrical line to ground fault current.
- 4.4.4 In calculations of the grid current, the current division factor must be assumed to be 1.0 unless calculations based on known actual site conditions are provided to justify a lower number.

Commentary 4.4.4:

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

- 4.4.5 For calculations of allowable step and touch potentials, the resistivity of the surface material (ρ_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.
- 4.4.6 Calculations of mesh voltage and ground potential rise (See IEEE 80) shall be based on actual measured soil resistivity. If native material is replaced by fill, calculations shall incorporate the effect of the measured soil resistivity of the fill.

Commentary Note 4.4.6:

IEEE 399 "IEEE Recommended Practice for Power Systems Analysis (Brown Book) provides additional information on analysis of ground grids for substations. The techniques covered in IEEE 80 are most useful for analyzing and designing ground grids for substations connected to solidly grounded high voltage lines. The guidance in NEC and this standard will be most useful in other portions of the electrical system.

- 4.5 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.
- 4.6 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.

5 Materials and Installation

This section also applies to electrical installations in residential facilities, 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:
- Be soft or annealed copper.
 - If larger than 35 mm² (#2 AWG) be stranded. Stranding of ground conductors shall comply with the stranding requirements of [SAES-P-104](#).
 - Except for grid conductors used in substations for potential control purposes be insulated when used in direct contact with soil less than 70 ohm-meters resistivity.
 - If used for grid conductors in substations for potential control purposes be bare and if used in soils less than 70 ohm-meters resistivity be tinned.
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- e) If insulated have a green jacket or a green jacket with yellow stripes. When isolated ground equipment grounding conductors are installed per IEEE 1100, they must be labeled or color coded to distinguish them from standard equipment grounding conductors.
- f) If exposed above grade in a severe corrosion area (as defined in [SAES-P-104](#)) be insulated.
- g) If buried and used for grids and/or interconnection of ground rods be minimum 70 mm² (2/0 AWG).
- h) If used for connection of equipment to ground rods or ground grid be minimum 25 mm² (#4 AWG).

Exception 5.1:

See [SAES-P-107](#) for pole ground wires.

Commentary Note 5.1:

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. Where insulated ground conductors are used, enough ground rods must be used to achieve the specified ground resistance. Insulated ground conductors are not suitable for use in substation ground grids to mitigate high levels of ground potential rise.

5.2 Ground rods shall have the following characteristics:

- a) Be copper or copper jacketed steel or galvanized steel. Copper jacketed steel ("Copperweld" or equivalent) shall meet the requirements of UL 467.
- b) If galvanized steel, only be 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) For copper or copper jacketed steel rods be a minimum of 16 mm in diameter and for 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 required ground rod shall be replaced with a zinc or magnesium anode and 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 e):

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 approved compression grounding connectors.
 - c) For connections at ground test stations only where it is necessary to disconnect ground conductors for tests, approved mechanical connectors may be used.

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 using compression type connectors bolted to bare steel, by thermite welding, or by other approved means.
- 5.5 Grounding conductors which do not accompany associated power conductors in the same conduit shall not be installed in metallic conduit except where PVC conduit is not suitable and it is necessary to protect the conductor from mechanical damage. Grounding conductors installed in metallic conduit or sleeves that do not accompany associated power conductors shall be bonded to both ends of the conduit.
- 5.6 Grounding conductors extending through concrete or asphalt shall be run in PVC conduit (preferred) or PVC coated rigid steel conduit. Grounding conductors in steel conduit shall be bonded as noted in Paragraph 5.5.
- 5.7 Underground ground conductors shall be insulated when within 3 meters of a buried metal pipeline or metal piping.
- 5.8 Underground ground conductors electrically connected to buried metal pipelines, buried metal vessels, or metal tanks sitting on grade shall be insulated. The associated ground rods shall be galvanized steel if the area is subject to cathodic protection.
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6 Substation Grounding

- 6.1 For substations having equipment operating at a nominal system voltage exceeding 1,000 Volts, a ground grid meeting the requirements of IEEE 80 for step and touch potential shall be installed. 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 cable.

7 Grounding Electrodes

- 7.1 Grounding electrode systems, including those for residential facilities, recreational facilities, schools, and office buildings, shall be in accordance with the NEC with the following additions:
- 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 5.3. 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 (bare or covered) used to interconnect rods or other made electrodes.

- 7.2 Supplementary grounding electrodes per NEC 250-54 shall be provided in outdoor industrial areas, process plant areas, and in substations not covered by Paragraph 6.1. In areas where no electrical equipment is installed, this supplementary grounding is not required unless otherwise specified. Supplementary electrodes shall consist of ground rods connected by bare or covered conductors, bare ground conductors, or combinations. Resistance to ground of each supplementary grounding electrode system shall meet the minimum requirements of NEC Article 250-56 for made electrodes. Where multiple items of equipment are connected, the supplementary grounding electrodes shall be interconnected using bare or insulated conductors to form grids or loops. The grids or loops shall be buried a minimum of 460 mm. This grounding electrode shall be bonded to the equipment grounding system in the area and may constitute a made electrode required to meet NEC requirements.
- 7.3 If an above ground bus or loop is used for extending the supplementary electrode, this bus or loop shall have two connections to the supplementary electrode.

8 System Grounding

- 8.1 Three-phase electrical systems shall be grounded at the neutral point of the wye-connected windings of the transformers or generators and connected as directly as possible to the grid or grounding electrode. The system grounding connections shall be made directly to the grounding electrode and be routed separately from equipment grounding connections.

Exceptions:

Three-phase 120/208 V 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 The type of system grounding shall be selected per Table 1.

Table 1 – System Grounding

Nominal Voltage	Type Distribution	Type Grounding	Requirements
240/120	Three-Wire	Solid	Ground center of 240 V winding
208/120	Four-Wire	Solid	
480	Three-Wire	Solid	See Note 1
480/277	Four-Wire	Solid	
4160	Three-Wire	Low Resistance	400 A, 10 Second Resistor
13,800	Three-Wire	Low Resistance	400 A, 10 Second Resistor (See Note 2)
13,800	Three-Wire	Low-Resistance	1000 A, 10 Second Resistor (See Note 2)
34,500	Three-Wire	Solid	
69,000	Three-Wire	Solid	

Notes:

1. High resistance grounding for 480 V systems is permitted with approval of the Electrical Standards Committee Chairman.
2. Selection of rating for 13,800 V system grounding resistor shall be done by or with the concurrence of Coordinator, Relay & Operations Engineering Division, Power Distribution Department.
3. See [SAES-P-100](#) for approval requirements for extension of ungrounded systems.
4. Except as noted systems originate from wye connected transformer secondary.

8.3 The ground resistance of made electrodes (ground rods and/or ground grid) used for system grounding shall not exceed 1 ohm for solidly grounded systems above 600 V, 5 ohms for resistance grounded systems above 600V and 5 ohms for systems under 600 V. In all cases step and touch potentials during ground faults shall not exceed the safe values defined in IEEE 80.

8.4 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.

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

Commentary Note 8.5:

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

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- 8.6 High resistance grounding of 480 V three-wire systems is permitted with the concurrence of the proponent and the approval of the Electrical Standards Committee Chairman.
- 8.6.1 High resistance grounding is only permitted in plants and bulk distribution facilities where full time maintenance or operations personnel are available and capable of responding to, and isolating, a ground fault within one hour of an alarm. Equipment for rapid location of ground faults must be provided as part of the high resistance grounding system. Additionally, relays capable of quickly sensing and isolating a second ground fault shall be provided.
- 8.6.2 Two hundred seventy seven (277) VAC neutral loads are not permitted.
- 8.6.3 When requesting approval for high resistance grounding systems, the following must be submitted:
- Details of ground fault alarm system,
 - details of the fault locating apparatus,
 - details of the protection scheme,
 - calculations or measurements for selection of grounding resistor, and
 - concurrence of the proponent that the level of response to ground faults required by paragraph 8.6.1 will be provided.

9 Equipment Grounding

- 9.1 Except as otherwise noted below, conduit, cable tray, or cable armor, shall not be relied on as the equipment grounding conductor and a bare or insulated copper conductor shall be installed in the same conduit, cable tray, cable, or cord or shall otherwise accompany the power conductors. 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. 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.

Exceptions:

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.

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 250-142.

9.1.1 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. On other 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 250-122 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.

9.1.2 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:

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

9.1.3 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.

9.1.4 Armored submarine cables do not require equipment grounding conductors.

9.2 Shields and armor of power cable shall be grounded at both ends. Continuity at splices shall be maintained by bonding across the splice.

Commentary 9.2:

Installation of voltage limiters may be necessary if cable shields and armor are not grounded at both ends.

9.3 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 approved grounding clamps and conductors connected externally to the conduit or
- by bonding to a grounded enclosure using integral threaded bushings or using a conduit hub (15-287-xxx or equal) which is approved for grounding purposes or
- bonding to a grounding conductor using an approved grounding bushing (15-287-409 or similar). Grounding with locknuts is not acceptable. or
- 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 9.3:

Where EMT is permitted it may be grounded and bonded using any means accepted by 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.

9.4 Metallic cable trays shall be bonded at both end points and a minimum of every 25 m to the local ground grid or ground electrode or to structural steel which is bonded to the local ground grid or ground electrode.

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

- 9.6 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.
- 9.7 Raised computer floors shall be grounded by bonding a minimum of two pedestals at opposite corners to the nearest grounding electrode. Refer to IEEE 1100 for guidance on grounding of raised floors used with sensitive electronic equipment.
- 9.8 The following equipment shall be connected to the local supplementary grounding electrodes described in Paragraph 7.2. This is in addition to equipment grounding conductors running with the power conductors that are required by the NEC and this standard.

Exception:

See Chapter 10 for supplementary grounding on offshore platforms.

- 9.8.1 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.
 - 9.8.2 Frames of equipment (motors, generators and transformers) operating at 1000 V or greater shall have two connections to a supplementary electrode.
 - 9.8.3 Motors, transformers, and generators operating at a nominal voltage of 480 V shall have a minimum of one connection to a supplementary grounding electrode.
 - 9.8.4 The following equipment when not bolted to grounded structural steel shall be connected to a supplementary grounding electrode:
 - 9.8.4.1 Metallic enclosures for panelboards, circuit breakers, switches, fuses, motor controllers, switchgear, switchracks, motor control centers, and motors and transformers not covered above.
 - 9.8.4.2 Metal vessels, stacks, exchangers and similar equipment.
 - 9.8.4.3 Loading and unloading facilities.
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- 9.9 Manually operated switches for overhead power lines shall have operating platforms and be grounded as shown on standard drawing [AA-036572](#).

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. 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. 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.
- 10.2 Equipment grounding shall be done per Chapter 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.
- 10.3 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 (APCS-19A; 09-612-345 or similar) 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. 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.

11.2.2 Fences that pass under a transmission line operating at 69 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.

11.2.3 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:

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 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

Lightning protection system design and installation shall be based on NFPA 780 and UL 96A or IEC 61662, IEC 61024-1, and IEC 61024-1-1.

The following buildings and occupied structures shall be provided with a lightning protection system:

- a) Buildings and occupied structures over 30 m in height;
- b) Schools;
- c) Hospitals;
- d) Buildings and occupied structures where the assessment of risk is as follows:
 - 1) Risk index of four or greater, if calculated in accordance with NFPA 780, Appendix H; or
 - 2) The risk of damage to a structure is greater than 1 in 10,000 per year and the risk to human life is greater than 1 in 100,000 per year, if calculated in accordance with IEC 61662.

Unless specified as higher for a specific location, an isokeraunic level of 10 or an annual ground flash density N_g of 0.71 per km² shall be used for calculations.

Lightning protection components shall be UL Listed or Labeled in accordance with UL 96 for lightning protection service or have approved equivalent certification. Protection systems design for 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

30 September, 2003	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor changes.
30 November, 2003	Minor revision.
28 January, 2004	Minor revision.