Engineering Standard

SAES-P-107 19 October 2008

Overhead Distribution Systems

Electrical Systems Designs and Automation Standards Committee Members
Hamrani, Majed Muhsen, Chairman
Sultan, Mansour Ramadan, Vice Chairman
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Primary contact: Hamrani, Majed Muhsen on 44-118-9135640

1 Scope

This Standard prescribes minimum mandatory requirements for the design and installation of overhead distribution systems rated through 34.5 kV. This document may not be attached to nor made a part of purchase orders.

2 Conflicts and Deviations

2.1 Any conflicts between this Standard and other Mandatory Saudi Aramco Engineering Requirements (MSAERs*) or referenced industry standards shall be resolved in writing by the Chairman, Electrical Systems Designs & Automation Standards Committee, Consulting Services Department, Saudi Aramco, Dhahran.

* *Examples of MSAERs are Saudi Aramco Materials System Specifications (SAMSSs), Engineering Standards (SAESs) and Standard Drawings (SASDs).*

2.2 Deviation from this Standard shall be approved by the Chairman, Electrical Systems Designs & Automation Standards Committee, Consulting Services Department, Saudi Aramco, Dhahran, and shall follow Saudi Aramco procedure SAEP-302.

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 SAMSS.

3 References

All referenced Standards, Specifications, Codes, Forms, Drawings, and similar material shall be of the latest issue (including all revisions, addenda, and supplements) unless stated otherwise.

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-064	*Onshore and Nearshore Pipeline Safety*

SAES-P-104	*Wiring Methods and Materials*
SAES-T-903	*Telecommunications Outside Plant Electrical Protection and Grounding*

The following SAMSSs and drawings are applicable to overhead line construction:

Saudi Aramco Materials System Specifications

14-SAMSS-600	*Material, Manufacture, and Preservation of Wood Poles*
14-SAMSS-602	*Material, Manufacture, and Preservative Treatment of Wood Crossarms*

Saudi Aramco Standard Drawings

AE-036014	*Pole Setting (2 Sheets)*
AA-036015	*Armless Construction, Double Deadend Structure, 2.4, 4.16, 13.8, and 34.5 kV*
AD-036016	*Bonding Details, Armless Construction, Angle Structure, 60 to 90 deg*
AC-036021	*Armless Construction, Angle Structure, 15 to 30 deg, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036022	*Armless Construction, Angle Structure, 60 to 90 deg, 2.4, 4.16, 13.8, and 34.5 kV*
AD-036023	*Guy and Anchors, Down Guys (3 Sheets)*
AE-036034	*Pole Footing Increased Bearing Area*
AE-036036	*Pole Rake*
AE-036037	*Pole Protection Guard*
AD-036063	*Guy and Anchors, 10.8 k Sidewalk Guy Installation*
AD-036064	*Guy Anchors Power Installed Screw*
AD-036066	*Guy and Anchors, 8 k Overhead Guy (3 Sheets)*
AD-036070	*Rock Anchor Installation*
AC-036079	*Armless Construction, Tangent Structure, 0 to 2 deg, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036085	*Armless Construction, Angle Structure, 0 to 15 deg, 2.4, 4.16, 13.8, and 34.5kV*

AC-036102	*Armless Construction, Angle Structure, 30 to 60 deg, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036104	*Armless Construction, Full Deadend Structure, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036112	*Armless Construction, 3-Phase Tap Structure, 2.4, 4.16, 13.8, and 34.5 kV*
AA-036121 Sh. 1	*Deadend Riser Pole with Fuse Disconnect*
AA-036121 Sh. 2	*Tap-Off Tangent Riser Pole with Fuse Disconnect*
AD-036133	*Switch Grounding Detail*
AD-036135	*Bonding Details, Post Insulators*
AD-036136	*Bonding Details, Armless Construction, Angle Structure, 30 to 60 deg*
AA-036390	*Deadend/Tap-off Pole with Transformer Installation (2 sheets)*

3.2 National Standards

Kingdom of Saudi Arabia Ministry of Transportation

Highway Design Manual

3.3 Industry Codes and Standards

American National Standards Institute

ANSI/IEEE C2	*National Electrical Safety Code (NESC)*
ANSI/NFPA 70	*National Electrical Code (NEC)*
ANSI O5.1	*Wood Poles - Specifications and Dimensions*
ANSI C29.1	*Electrical Power Insulators - Test Methods*
ANSI C29.2	*Insulators - Wet-Process Porcelain and Toughened Glass - Suspension Type*
ANSI C29.4	*Wet-Process Porcelain Insulators - Strain Type*
ANSI/NEMA C29.7	*Porcelain Insulators - High-Voltage Line-Post Type*
ANSI/NEMA C29.9	*Wet-Process Porcelain Insulators - Apparatus, Post-Type*

American Society for Testing Materials

ASTM B549 *Standard Specification for Concentric-Lay-Stranded Aluminum Conductors, Aluminum-Clad Steel Reinforced (ACSR/AW)*

4 General

4.1 Overhead distribution systems shall be in accordance with ANSI/IEEE C2 (NESC), as supplemented by this Standard and the Saudi Aramco standard drawings listed above.

4.2 Overhead lines shall be designed and constructed to NESC Grade B requirements for light loading conditions.

4.3 Overhead line design shall be based on the following environmental conditions:

Minimum temperature : 0°C
Maximum temperature : 50°C
Wind speed (50 yr.) : 160 km/hr

Exception:

In specific locations covered by SAES-A-112, environmental data from SAES-A-112 may be used with concurrence of Coordinator, CSD/Electrical Systems Division.

4.4 The following shall be submitted to Coordinator, CSD/Electrical Systems Division for review during detailed design of new overhead distribution lines which exceed 5 spans in length:

Sag and tension calculations
Sag/Temperature Templates
Plan and profile drawings

Exception:

Plan and profile drawings are not required if:

1) The changes in elevation between any two poles would not result in variations of more than 2 meters in the vertical clearance of the lowest conductor. (i.e., the terrain is flat).

2) The span lengths do not exceed 90 m.

3) Drawings are provided that show the route of the line.

Commentary Note 4.4:

Distribution line spans should normally not exceed 90 m in length. Vertical clearances required by Section 4.7 of this standard must be maintained regardless of terrain variations.

4.5 Compression type (gripping force is provided by compressing the connector onto the conductor using a tool designed for the purpose and is non-reversable) connectors shall be used for splicing and tapping. Connectors for aluminum (ACSR) conductors shall be filled with an oxide inhibiting and sealing compound such as Burndy PENETROX.

4.5.1 Compression type lugs shall be used for overhead line connections to equipment furnished with pad type terminals.

4.5.2 Compression lugs or splices used for connections of insulated or covered cables to overhead lines shall have a closed barrel or solid center stop to prevent ingress of water into the insulated cable.

4.6 Non-current carrying metallic enclosures, brackets, and braces shall be bonded together via grounding lugs and shall be connected to a grounding electrode conductor. Pole ground conductors shall be minimum 4 AWG, stranded, soft drawn, bare copper. Refer to AA-036015, AD-036016, AD-036135 and/or AD-036136 for details.

4.7 Vertical clearances above grade for desert installations of conductors, including service drops, messengers, and guys shall be minimum 8.5 m at final unloaded sag, no wind, and 50°C ambient temperature. For designs using emergency service conditions, minimum vertical clearance shall be calculated using 120°C total conductor temperature. In plants, construction camps, residential areas, and other non-desert areas minimum clearance shall be per ANSI/IEEE C2 unless larger clearances are required by the facility proponent.

4.8 Vertical clearances above grade for plant entrances shall be determined by the proponent. Minimum clearance shall be 8.5 m under the conditions specified in Paragraph 4.7 above.

4.9 Aerial-to-underground transitions shall be in rigid galvanized steel conduit or PVC coated galvanized rigid steel conduit in accordance with the requirements of SAES-P-104.

4.10 See SAES-B-064 for requirements relating to horizontal clearances between pipelines and powerline conductors and for horizontal clearances between pipelines and powerline support structures.

4.11 Designs for single phase circuits shall include provisions for future conversion to three phase without requiring additional design work. Clearances, pole heights, guys, crossarm dimensions, pole loadings, etc., shall be designed assuming addition of a third phase conductor identical to those being installed.

Exception:

Not required if proponent of the line verifies that future upgrade of the line will not be necessary.

5 Supporting Structures

5.1 Supporting structures for overhead lines shall hotdipped galvanized steel or seamless aluminum alloy poles in plants and other industrial facilities and fiberglass poles or wood poles meeting the requirements of 14-SAMSS-600 for non-industrial locations.

Exception:

Wood poles shall be permitted for use in stand alone Water Injection Plants, Water Treatment Plants, and for supply lines located outside of industrial and plant areas (for example, Cathodic Protection supply lines in desert areas).

5.2 Wood poles used for supporting structures shall be Class 4 or better as defined in ANSI O5.1.

5.3 Supporting structure, guy, messenger, and anchor locations shall be selected based on accessibility, limited use of guys, minimal obstructions to pedestrian and vehicular traffic, and shall be as inconspicuous as possible.

5.4 Where required (as determined by the Superintendent of the Area Loss Prevention Division and the proponent organization), supporting structures located less than 9 m from a roadway shall be protected by barriers meeting the requirements of the Highway Design Manual, Volume 2, Part 1, Section 1.15. Supporting structure clearance from curbs shall be maintained at a minimum of 0.6 m from face of curb.

5.5 Wood supporting structures shall have a dating nail indicating the year of installation located at approximately 2 m above grade

5.6 Setting depths for wood poles shall be as shown on standard drawing AE-036014.

5.7 Support structures shared by power conductors and communications cables shall also meet requirements of SAES-T-903.

6 Armless Construction

6.1 Armless type construction shall be used for the conductor support system (See referenced Standard Drawings).

Commentary Note 6.1:

"Armless" refers to the general type of construction. Crossarms may be used for deadend structures, tap-off structures, etc., in accordance with the referenced standard drawings.

6.2 Horizontal loading for line post insulators shall not exceed 2.2 kN for initial sag at the minimum temperature per paragraph 4.3, and wind loading of 430 pa.

6.3 Line conductors up to 336.4 kcmil ACSR shall be dead-ended for line angles larger than 30°. Line conductors 336.4 kcmil and larger shall be dead-ended for line angles larger than 5°.

6.4 Lines more than 2 km long shall be double dead-ended a minimum of every 1.5 km.

7 Guys, Messengers and Anchors

7.1 All materials and dimensions shall withstand loads developed from sag conditions at the minimum temperature per paragraph 4.3. Strand ultimate strength shall be the weakest component of guy and messenger assemblies.

7.2 The angle between a down-guy and the supporting structure shall not exceed 60°.

7.3 The use of sidewalk guys shall be limited to supporting structure loads of less than 6.6 kN. Sidewalk guy horizontal member shall consist of a 2 in galvanized pipe at a minimum height of 2.4 m above grade.

7.4 Sidewalk guys shall have reflective finished guy guards with the open side of the guard facing away from the sidewalk.

7.5 Overhead guys shall be connected to the supporting structure grounding electrode conductor at both ends. Down guys shall be connected at the upper end.

7.6 Guys from supporting structures having ungrounded or resistance grounded circuits shall be insulated with strain insulators.

7.7 For installations where a section of the guy crosses under or over supply conductor circuits connected to other supporting structures rated in excess of 300 V, or which pass within a 3 m radius of such circuit conductors, the guy

section shall be insulated from ground. The exposed section shall be isolated from points within 1.8 m of the supporting structure. Insulators shall be located a minimum of 2.4 m above grade and below the lowest power conductor.

7.8 Guy insulators shall not be used with guy strands having ultimate strengths greater than 80 kN.

7.9 Guy insulators shall have a rated ultimate strength greater than the rated breaking strength of the guy.

7.10 Insulators are not required for messengers supporting street lighting cables, secondary conductors of series lighting circuits, and traffic signal conductors.

7.11 Guy and messenger attachment hardware shall be preformed type dead end fittings or automatic guy grips.

7.12 Messengers shall be of the stranded steel type. Messengers shall be sized for the ultimate number of cables to be installed.

7.13 Power-installed screw anchors or rock anchors shall be used, except in hard marl soil where expanding type anchors are permitted. Anchors shall not be loaded in excess of 35% of their ultimate allowable holding strength. If required for holding in poor soils, other anchor designs may be used with the concurrence of Coordinator, Electrical Systems Division, Consulting Services Department.

7.14 Anchors shall not extend above ground in excess of the length necessary for attachment requirements.

8 Insulator Requirements

8.1 Except where specifically noted otherwise in this document or the referenced standard drawings, minimum insulator creepage for components shall be 40 mm per kV line-to-line nominal system voltage.

8.2 Post and suspension type insulators shall be used. Pin type insulators shall not be used. Insulator brackets shall be metallic. Semiconducting or resistive glaze insulators shall not be used.

8.3 Insulators used on overhead distribution systems shall meet the requirements of the ANSI C29 series of standards. Specifically: (1) Insulators shall be tested in accordance with C29.1; (2) Suspension type insulators shall be in accordance with ANSI C29.2; (3) Strain type insulators shall be in accordance with ANSI C29.4; (4) Line-post type insulators shall be in accordance with ANSI/NEMA C29.7; (5) Station-post type insulators shall be in accordance with ANSI C29.9; (6) Preferred insulator color is chocolate brown.

8.4 Insulators shall not be loaded in excess of 40% of their rated ultimate strength.

8.5 Fog type porcelain suspension insulators shall be used to terminate overhead circuits at a substation bay or supporting strain bus. For these applications, an insulating string shall consist of a minimum of 2 units at 13.8 kV and 4 units at 34.5 kV.

9 Primary Conductors

9.1 Conductors shall be ACSR/AW (aluminum conductor, aluminum clad steel reinforced)/AW per ASTM B549 and Table 1.

Table 1

Code Word	mm²	Awg	Kcmil
SWAN/AW	21.1	4	41.7
SPARROW/AW	33.6	2	66.36
RAVEN/AW	53.5	1/0	105.6
QUAIL/AW	67.4	2/0	133.1
PENGUIN/AW	107.2	4/0	211.6
MERLIN/AW	170.2		336.4
ORIOLE/AW	170.5		336.4
DRAKE/AW	402.8		795.0

9.2 Phase rotation shall be x y z (a b c) counterclockwise.

9.3 Phase positions shall be per Table 2.

Table 2

Construction	Phase/Neutral	Position
HORIZONTAL	X OR A	EAST OR NORTH
	Y OR B	CENTER
	Z OR C	WEST OR SOUTH
	NEUTRAL OR SOUTH	BELOW, EAST
VERTICAL	X OR A	TOP
	Y OR B	CENTER
	Z OR C	BOTTOM
	NEUTRAL	BELOW

9.4 Bare conductor rated ampacities shall be as per Table 3.

Table 3

Code Word	Kcmil	Service Condition	
		Normal (Amperes)	Emergency (Amperes)
SWAN/AW	41.74	110	165
SPARROW/AW	66.36	150	215
RAVEN/AW	105.6	200	300
QUAIL/AW	133.1	260	335
PENGUIN/AW	211.6	305	445
MERLIN/AW	336.4	440	650
RAKE/AW	795.0	760	1105

Table 3 Notes:

(1) Normal service conditions are defined as follows:
80°C conductor temperature
50°C ambient temperature
0.6 m/sec wind velocity

(2) Emergency service conditions are defined as follows:
120°C conductor temperature
50°C ambient temperature
0.6 m/sec wind velocity

(3) Radial lines shall be designed based on normal service conditions for the maximum operating load. Distribution loops and lines feeding double-ended substations shall be designed using normal service conditions.

Exception:

The emergency service conditions may be used for designing for abnormal operation during outages which cause a distribution loop to be fed from only one end or a double ended substation to be fed from one line only.

9.5 Conductor tension shall not exceed 10% of the conductor ultimate strength. Sag and tension calculations shall be based on maximum and minimum ambient temperatures per Paragraph 4.3. For lines subject to emergency service conditions, maximum sag shall be calculated based on emergency service conditions shown in Paragraph 9.4 Note 2.

9.6 Overhead ground wires terminating on a substation structure shall be connected to an equivalent cross section copper conductor which is connected to the ground grid or bus.

10 Accessory Equipment

10.1 Accessories, including terminating devices, shall be rated for application at line-to-line system voltages.

10.2 Transformer primary connections shall be made with hot line clamps connected to a bail (stirrup) compressed on the line conductor.

10.3 Minimum height between any part of a pole mounted transformer or its mounting bracket or platform and grade shall be 4.9 m.

10.4 Supporting structures for accessories shall have a minimum stress safety factor of 4.0.

10.5 Minimum separation between ungrounded conductors shall be per Table 4.

Table 4

System Voltage (kV)	Clearance mm
4.16	230
13.8	410
34.5	710

10.6 Loadbreak switches shall be provided at sectionalizing points.

11 Protective Devices

11.1 Surge arresters shall be installed at distribution transformer installations, capacitor bank installations, recloser installations, metering installations, and aerial-to-underground cable termination points.

11.2 Surge arresters shall be of the distribution class, metal-oxide, gapless type rated per Table 5.

Table 5

System Voltage (kV)	Arrester Rating (kV)
4.16	6.0
13.8	12
34.5	27

11.3 The grounding electrode for surge arresters shall be minimum 16 mm (5/8 in) diameter by 3 m (10 ft) local copper or copper clad ground rod(s) driven along the center line of the circuit. The ground rod(s) shall also be bonded to the plant or substation ground grid if located within 15 m of the rod. The resistance to ground of the surge arrester ground shall not exceed 25 ohms. The surge

arrester grounding terminals shall be connected, with minimum bends, directly to the local ground rod.

11.4 Minimum arrester-to-arrester clearance shall be per Table 4.

11.5 Fused cutouts shall be provided for transformers fed directly from overhead distribution lines.

11.6 Loadbreak switches and fused cutouts shall be provided for capacitor installations on overhead distribution lines.

Revision Summary

7 April 2008	Revised the "Next Planned Update". Reaffirmed the contents of the document and reissued with editorial revisions.
19 October 2008	Editorial revision to replace Electrical Systems Designs and Automation Standards Committee Chairman and Vice Chairman.