Engineering Standard

SAES-P-119 5 November 2012

Substations

Document Responsibility: Electrical Substations Equipment Stds. Committee

Saudi Aramco DeskTop Standards

Table of Contents

Primary contact: Ishwait, Basel A. on +966-3-8809664

1 Scope

This standard presents the mandatory requirements for the design and installation of onshore and when specifically specified in this standard, offshore power substations. This document may not be attached to nor made a part of purchase orders.

2 Conflicts and Deviations

2.1 If there are any conflicts between this Standard and associated project or engineering documents, this standard shall take precedence. The exception is if an approved Waiver Request has been included with the purchasing documents.

2.2 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.

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

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

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-014	*Safety Requirements for Plant and Operations Support Buildings*
SAES-B-055	*Plant Layout*
SAES-K-001	*Heat Ventilating and Air Conditioning*
SAES-K-002	*Air Conditioning Systems for Essential Operating Facilities*
SAES-M-006	*Saudi Aramco Security and General Purpose Fencing*
SAES-M-100	*Saudi Aramco Building Code*
SAES-O-100	*General Requirements Safety and Security*
SAES-O-109	*Minimum Standards for Buildings Housing Sensitive or Vital Equipment*
SAES-P-100	*Basic Power System Design Criteria*
SAES-P-101	*Regulated Vendors List for Electrical Equipment*
SAES-P-103	*Direct Current and UPS Systems*
SAES-P-111	*Grounding*
SAES-P-116	*Switchgear and Control Equipment*
SAES-P-123	*Lighting*
SAES-P-126	*Power Monitoring System*
SAES-Q-006	*Asphalt Concrete Paving*
SAES-S-020	*Industrial Drainage and Sewers*

Saudi Aramco Materials System Specifications

14-SAMSS-536	*Pad-Mounted Three-Phase Distribution Transformers*
16-SAMSS-502	*Metal-Enclosed Low-Voltage Switchgear Assemblies*
16-SAMSS-503	*Indoor Controlgear - Low Voltage*
16-SAMSS-504	*Indoor Metal-Clad Switchgear 1 to 38 kV*
16-SAMSS-506	*Indoor Controlgear - High Voltage*
16-SAMSS-508	*SF_6 Gas Insulated Circuit Breakers, Outdoor - 34.5 kV through 230 kV*

16-SAMSS-510	*Manually Operated Pad Mounted SF_6 Switchgear: 1 kV to 36 kV*
16-SAMSS-514	*Control and Protective Relay Panel - Indoor*
34-SAMSS-815	*Annunciators*

Saudi Aramco Standard Drawing

AB-036319	*Standard Sign: Danger High Voltage*

Saudi Aramco Library Drawings

DA-950151 to DA-950163	*Standard Substation Building Design*

Saudi Aramco Best Practice

SABP-P-034	*Substation Bus Configurations*

3.2 Industry Codes and Standards

American National Standards Institute

ANSI C2	*National Electrical Safety Code*
ANSI/NFPA 70	*National Electrical Code*
ANSI/IEEE 979	*IEEE Guide for Substation Fire Protection*
ANSI/IEEE 980	*IEEE Guide for Containment and Control of Oil Spills in Substations*
IEEE C37.1 - 1994	*IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automatic Control*
IEEE 605 - 1998	*IEEE Guide for Design of Substation Rigid-Bus Structures*
IEEE 998 - 1996	*IEEE Guide for Direct Lighting Stroke Shielding of Substations*

4 Definitions

Controlgear: is equipment manufactured to either 16-SAMSS-506 (Indoor Controlgear - High Voltage) or 16-SAMSS-503 (Indoor Controlgear-Low Voltage).

Secondary-Selective: A **switchgear** assembly consisting of two buses connected with a single **bus tie breaker**. Each bus has one breaker to receive incoming power. (i.e., power flow into and between the two busses is controlled with three breakers). Also, referred to as “double-ended” switchgear.

Switchgear: Is equipment manufactured to either 16-SAMSS-502 (Metal-Enclosed Low-Voltage Switchgear Assemblies) or 16-SAMSS-504 (Indoor Metal-Clad Switchgear 1 to 38 kV).

Major Substation: Substation supplying power to Gas Plants, Refineries and major Oil Producing Facilities (e.g., Khurais, Manifa, RT Refinery).

Nominal Voltage: Refer to SAES-P-100 for definition.

Utilization Equipment: Refer to SAES-P-116 for definition.

5 General

5.1 Terms in **bold** font are defined within Section 4.

5.2 Saudi Aramco defines a substation as any assemblage of electrical equipment which includes a power transformer rated 751 kVA and larger or **switchgear** rated 1 kV and higher.

Exception:

This standard does not apply to manually operated pad-mounted switchgear manufactured to 16-SAMSS-510 or pad-mounted distribution transformers manufactured to 14-SAMSS-536.

Commentary Note 5.2:

See SAES-P-116 for guidance on equipment that is located in substation buildings.

5.3 Substations shall be in accordance with the ANSI/NFPA 70 (National Electric Code) and ANSI C2 (National Electrical Safety Code) as supplemented by this Standard.

5.4 Location of substation and substation equipment shall comply with SAES-B-055. Substations shall be located in non-classified areas.

5.5 Each substation building shall be provided with Annunciator/monitor panel(s) indicating the below status conditions. The annunciator panels shall be combinations of either:

5.5.1 Discrete annunciator panel(s) meeting the requirements of 34-SAMSS-815. A common trouble alarm shall be extended to a manned facility.

5.5.2 Monitors displaying information resident in local workstations.

5.5.3 The following status conditions to be displayed:

a) Loss of circuit breaker tripping supply (Minimum one alarm per bus)

b) Loss of **switchgear** protection supply (Minimum one alarm per bus)

c) Loss of circuit breaker SF_6 gas pressure

d) Low circuit breaker operating air pressure

e) Power transformer combustible gas present

f) Power transformer pressure relief valve operated

g) Power transformer Buchholz relay operated

h) Power transformer high winding temperature

i) Power transformer loss of reference potential on Automatic Voltage Regulator (AVR)

j) Power transformer loss of cooling fan supply voltage

k) Power transformer low transformer oil

l) Power transformer high oil temperature

m) Power transformer low tap changer oil level

n) Power transformer loss of tap changer motor operating supply

o) Power transformer tap changer failure

Commentary Note 5.5:

Alarms are equipment specific. Most substations will not have all of these alarms.

5.6 Tap changer, automatic voltage regulator, protection and circuit breaker control panels shall be located inside the substation building when associated equipment is located in an outdoor transformer yard or switchyard (e.g., transformer with an automatic tap changer or outdoor circuit breaker).

5.7 HV Control and Protection panels shall be supplied either by the circuit breaker manufacturer or an approved HV Control and Protection panel manufacturer, in conformance with SAES-P-101 and 16-SAMSS-514. Control and Protection panels shall be arranged as follows for each: Line protection and metering, Bus Bar Protection, Feeder Protection and metering, Circuit Breaker Bay Control including Breaker failure protection, and Automatic voltage regulation.
The panels shall be of simplex type having front door access with relays surface mounted on the door. Circuit breaker control and indication functions shall be arranged on the circuit breaker control panels to represent the substation configuration (e.g., Breaker and half, inverted PI, etc.) and be interconnected by a mimic line diagram indelibly represented on the surface of the panel with a maximum of one substation bay per panel

5.8 Substations shall have a grounding system meeting the requirements of SAES-P-111.

5.9 High voltage disconnect switches shall be manually operated double break, center rotation type located at the tubular bus level.

5.10 Substation bus configurations shall be as per Section 8.

6 Substation Buildings

6.1 Substation buildings shall be constructed in accordance with SAES-M-100 and SAES-B-014.

Commentary Note 6.1:

SAES-M-100 requires substation building to be constructed in accordance with Library Drawings DA-950151 - DA-950163 inclusive.

SAES-B-014 has specific requirements for buildings in near or associated with plants and may require a Building Risk Assessment Study that may affect the construction of the building.

6.2 Passageways shall be unobstructed and shall provide a minimum 2.3 m headroom.

6.3 Cable trays shall be installed as follows:

6.3.1 Parallel and at right angles to the building walls.

6.3.2 Minimum of 200 mm of vertical clearance shall be provided between cable trays.

6.3.3 The elevation of the bottom of the lowest interior cable tray shall be a minimum of 2.67 m above the main substation floor.

6.4 Conductors shall enter or exit through the building walls.

Exception 6.4:

Substation buildings housing Gas Insulated Switchgear (GIS) with 34.5 kV voltage rating and above.

6.5 Conductors shall enter the equipment from the top.

6.6 Maximum substation building length shall be limited to 50 meters.

Exception 6.6:

If written approval is obtained from the Consulting Services Department/Civil Engineering Unit, requests for approval must be accompanied by structural

design calculations verifying the buildings blast design capacity.

6.7 Exterior illumination shall consist of HID high pressure sodium type fixtures controlled by a photo cell. A Hand-Off-Automatic (HOA) selector switch shall be provided in accordance with SAES-P-123 requirements for exterior illumination controls.

6.8 All interior substation lighting shall be fed from different power supplies (i.e., fed from two different low voltage switchgear bus).

Commentary Note 6.8:

This requirement can be implemented by equally distributing the substation lights between two low voltage panelboards or feeding all substation lights from one panelboard fed from two different power supplies through manual Transfer Switch (TS).

6.9 Emergency interior illumination shall be provided by one of the following:

6.9.1 Self-contained, battery-powered emergency lighting units, with integral charger, which are automatically energized upon loss of 120 VAC power.

6.9.2 Uninterruptible Power Supply (UPS) system located in the substation.

6.10 Duplex, 3-wire, 20 A, 120 VAC convenience outlets shall be provided throughout the substation building. A minimum of one outlet shall be provided for each 6 m of wall space at 1 m above the floor. A minimum of two outlets per substation shall be provided.

6.11 Each substation building shall be provided with a redundant air-conditioning system in accordance with SAES-K-001 and SAES-K-002. The indoor temperature in battery rooms shall meet the requirements of SAES-K-002. For normally occupied substations, the office facility or other occupied area shall meet the indoor temperature requirements of SAES-K-001 for offices. Temperature requirements for unattended substations are also specified in SAES-K-001.

Commentary Note 6.11:

Unattended substations require a design maximum temperature of 35°C, however, the HVAC for the battery room is required to maintain 25°C.

6.12 Substation roof drainage shall not be to the transformer yard side of the substation building.

6.13 If a substation is to be constructed over existing pipelines, the substation floor shall be elevated a minimum of 1.8 m above grade. The space below the elevated substations shall have the following characteristics:

6.13.1 Be freely ventilated on at least three sides.

6.13.2 The ground below the building shall be at or above finished grade.

6.13.3 Be enclosed with grillwork suitable for the environmental conditions and a lockable gate to permit access only to authorized personnel. The grillwork and the gate shall be connected to the substation grounding system.

6.13.4 Shall not drain to the transformer yard side of the substation building.

6.13.5 The side of the building adjacent to the transformer yard shall have a solid wall (fire-rating the same as the building wall) that separates the space from *the transformer yard.*

Commentary Note:

Note that this specification does not allow cable or electrical raceways to enter/exit through the floor.

6.14 The concrete floor in front of **switchgear** shall be flush with the roller level of lower breaker carriage rack and have a smooth surface to facilitate removal and rolling of breaker. This floor area shall be surface hardened for rolling stock.

6.15 Underneath **switchgear** and **controlgear**, one of the following shall be provided to ensure the equipment is maintained on an even plane:

6.15.1 Leveling steel beams or channels. Design and installation of these channels shall be in accordance with the recommendations of the **switchgear** and **controlgear** manufacturer.

6.15.2 The floor shall be horizontal in both planes with a maximum surface height variation less than 5 mm per 3 meters.

6.16 Substation buildings shall have a minimum 2 hour fire rating and be constructed in accordance with SAES-M-100 and where required SAES-O-100 and SAES-O-109 standards.

6.17 A battery room and battery handling facilities shall be provided for stationary batteries in accordance with SAES-P-103.

6.18 Circuit breaker testing facilities and operating tools shall be provided and installed in the substation in accordance with SAES-P-116.

6.19 Substation buildings with single-ended **switchgear** shall be designed to accommodate future **double-ending**.

Commentary Note 6.19:

*Since providing for future **double-ending** will require additional floor space, this should be addressed in the design basis or project proposal documents.*

6.20 Substation buildings shall have a telephone and data communications. This shall include connection to the plant local area network. SAES-P-126 mandates a dedicated (stand lone) Ethernet network for the power monitoring system.

6.21 Substation buildings shall have provisions for mounting and protecting as-built key one-line diagrams for ready reference of operating personnel.

6.22 Substation buildings shall have smoke detection systems per SAES-B-014.

6.23 Substation buildings shall have Distributed Control System (DCS) Input/Output (I/O) ports available. This shall be implemented either by remote I/O racks(s) and/or DCS controllers within the substation. Design, installation and interconnection to plant DCS system shall be per the applicable SAES-J series of standards.

Commentary Note 6.23:

*SAES-P-116 and **controlgear** specifications require the **controlgear** be controlled via serial communication through these I/O ports. Other substation equipment may also use this I/O system to communicate to the DCS system.*

7 Substation Yard

7.1 For on-shore, outdoor installations, pad-mounted electrical equipment shall be placed on a level concrete pad, the top of which is elevated a minimum of 100 mm above natural grade. Unless greater clearances are specified by the NEC, the following minimum clearances shall apply:

7.1.1 A minimum working clearance of 2 meters on all sides.

7.1.2 A minimum working clearance of 3 meters on the sides of the equipment having doors or access panels which can be opened to expose live parts.

7.1.3 The intent of the above requirements is met by gate(s) which can be opened to provide the required clearance.

Exception:

Clearance between pad-mounted electrical equipment and fences or walls installed for the purpose of protecting the equipment from unauthorized access is permitted to be reduced to a minimum of 1 meter with the concurrence of the proponent, provided that the 3-meter

clearance is maintained for equipment doors and access panels required to be opened for normal maintenance and/or operations.

Commentary Note:

The above clearances are minimums, ANSI/NFPA 70 or equipment manufacturer may require greater clearances for some installations.

7.2 Transformer clearances and fire barriers shall be as follows:

7.2.1 For transformers containing 7570 liters and less of insulated oil: Clearance shall be per 7.1 above.

7.2.2 For transformers containing more than 7570 liter of insulated oil:

a) Separation from buildings

If the building has a fire rating; 6.1 meters or greater (Figure 1).

b) Separation between transformers.

If no fire barrier or barrier fire rating is less than 1 hour: greater than a minimum of 9.1 meters of clear space as specified in ANSI/IEEE 979 (Figure 2).

7.2.3 Fire barrier characteristics shall be as follows:

a) The height of a fire barrier shall not be less than 300 mm above the height of transformer tank, conservator (if applicable), transformer bushing, and pressure relief vents, etc. (Figure 1).

b) The fire barrier shall extend at least 600 mm horizontal beyond the line of sight between all points on adjacent transformers (Figure 1). The height of the fire barrier shall be enough to break the line-of-sight from any point on the top of the transformer and adjacent transformer as specified in ANSI/IEEE 979 (Figure 1).

7.3 Transformer oil containment/drainage shall be as follows:

7.3.1 For transformers containing 2500 liters or less of oil: No oil containment/drainage is required

7.3.2 For transformers containing more than 2500 liters of oil, the following oil containment/drainage system shall be provided:

a) Oil containment and drainage systems shall meet the general requirements of ANSI/IEEE 980 and the specific requirements of SAES-S-020.

b) For power transformers up to 2.5 MVA oil containment shall be in the form of toe walls of sufficient height and area to contain twice the oil volume of the transformer.

c) For power transformers 2.5 MVA and above oil containment shall be in the form of a concrete pit constructed around the transformer foundation. The pit shall be equipped with a steel grating covered with crushed rock to a minimum thickness of 300 mm for fire quenching and have the following characteristics:

i) The crushed rock shall be a minimum sieve size of 25 mm uniformly graded.

ii) The steel grading mesh size shall be less than 25 mm^2.

iii) A removable section, with a steel lid not covered with crushed rock, shall be provided in a corner of the steel grating to allow access for cleaning.

iv) A sump shall be provided at a corner of the pit for collection of rain water or oil. The sump shall have means of drainage either by suitable connection to sewers or other means of fluid removal.

Commentary Note 7.3.2:

Oil containment shall be designed to accommodate environmental conditions. Pits completely filled with crushed rock shall not be used since they must be made extremely large to contain the oil volume plus the crushed rock and they cannot be easily cleaned of wind blown sand accumulation.

7.4 Transformer Neutral Ground Resister (NGR) shall be located in the substation yard. NGR shall not be mounted on a transformer.

7.5 The substation yard shall be completely paved as a plant area in accordance with the requirements of SAES-Q-006. The thickness of the combined asphalt layers shall not be less than 10 cm.

Commentary Note 7.5:

The high surface resistivity of an asphalt-aggregate mixture under both wet and dry conditions reduces the number of ground grid conductors required to obtain safe step and touch potentials during ground faults.

7.6 Substation yards shall be enclosed. Fences shall be constructed in accordance with the requirements of SAES-M-006. Warning signs shall be in accordance

with Saudi Aramco Standard Drawing AB-036319 and shall be posted on the fence at intervals not to exceed 6 m.

7.7 Equipment located in the substation yard shall not be accessible from the roof of the substation building.

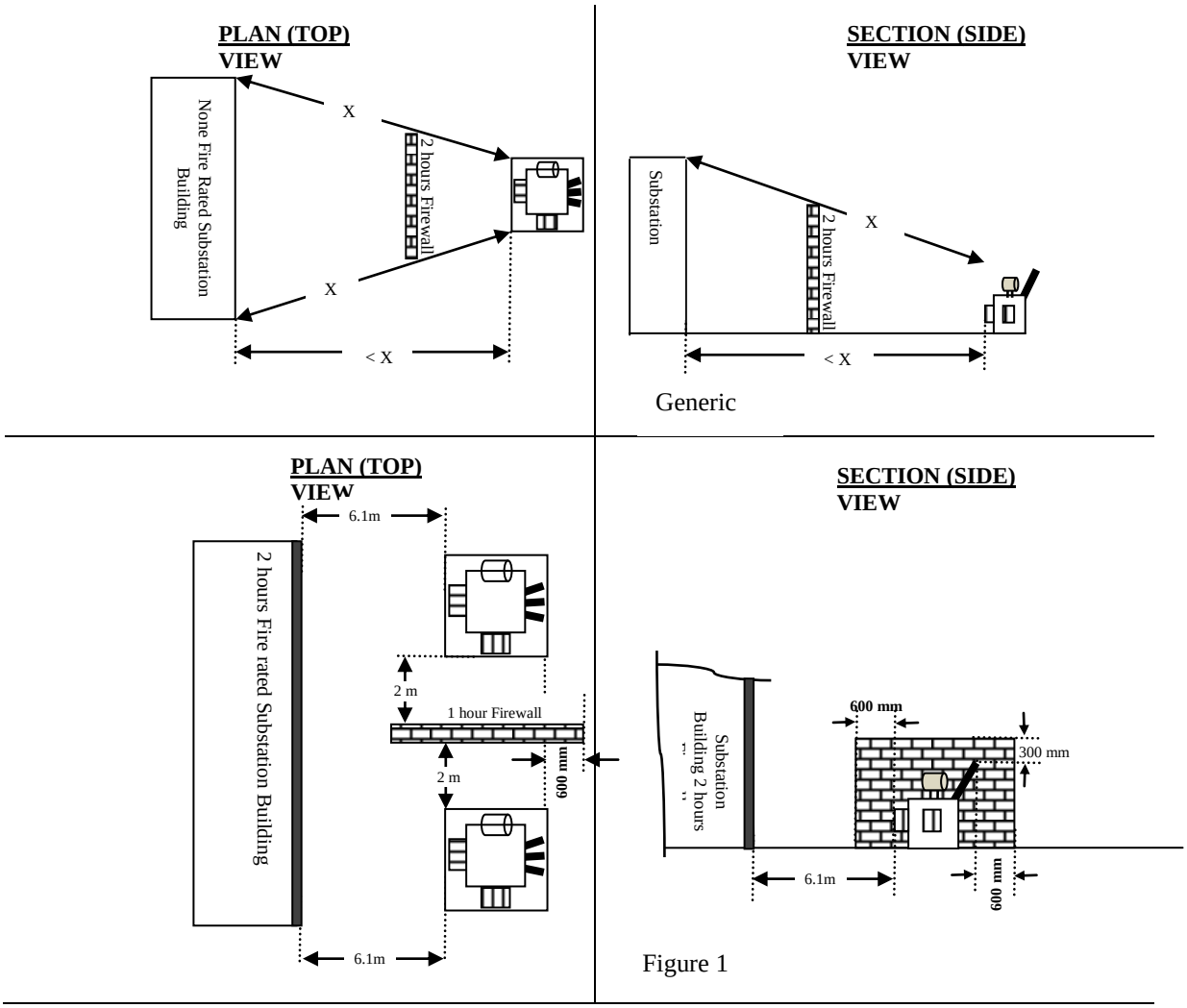

Figure 1

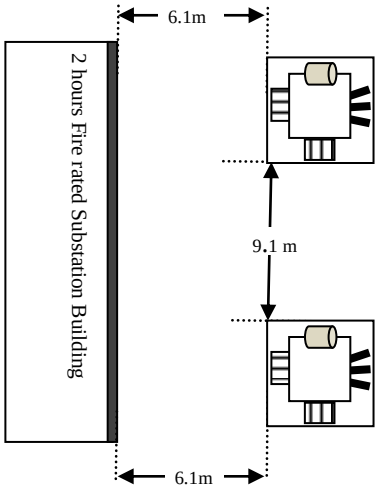

Figure 2

7.8 120 VAC utility receptacles shall be provided with the following characteristics:

7.8.1 Sufficient receptacles shall be installed inside and outside the substation building so that a receptacle is located within 6 m of each power circuit breaker (indoor and outdoor) and each power transformer.

7.8.2 Duplex, 3-wire, 20 A, 120 VAC.

7.8.3 Outdoor units shall be equipped with self-closing covers which are weatherproof when the covers are closed.

7.8.4 Outdoor receptacles shall be fed from a 20 A rated Ground Fault Circuit Breaker with 5 mA sensitivity. (i.e., receptacles with integral ground fault protection are not acceptable).

7.9 The outdoor high voltage substation and switchyard (69 kV and above) shall be in accordance with the following:

7.9.1 Bus Design

a) Outdoor Rigid Bus design shall be in accordance with IEEE Guide for Design of Substation Rigid-Bus Structures, IEEE 605 - 1998.

b) Bus conductors shall be manufactured from Schedule 40/80 seamless aluminum alloy tubing, temper 6063-T6.

c) Vertical bus deflection under maximum loading conditions, including the weight of vibration damping measures, shall be limited to 0.5% of span length.

d) Maximum horizontal span length between bus supports shall be 10 meters.

e) Vibration damping shall be accomplished by inserting stranded bare conductor inside the rigid bus tubing. The stranded conductor shall be of the same material as the tubing to prevent corrosion.

f) The rigid bus shall be joined by welding. Bolted joints in the tubular bus are not acceptable.

g) Connections to the tubular bus shall either be welded or via welded pads providing standard NEMA bolt pattern.

h) Flexible joints shall be provided to control expansion on bus runs longer than 30 meters.

i) Welded grounding lugs shall be provided on the bus tubing for the attachment of safety grounds. The ground lugs shall be located on the rigid bus on both sides of disconnect switches and circuit breakers.

j) Connection from rigid bus to circuit breakers shall be via stranded cable jumpers with compression fittings and NEMA bolt pattern for both the bus and circuit breaker connections.

k) Rigid bus supports shall be constructed from steel I-beam, steel pipe or square section steel tubing.

l) Composite bus support post type insulators shall be used comprising silicone rubber compound external insulation over a solid fiberglass core with ANSI/IEEE/NEMA bolt patterns.

7.9.2 Electrical clearances shall be in accordance with ANSI C2 (NESC).

7.9.3 Lightning shielding shall be per SAES-P-111.

7.9.4 The outdoor HV substation and switchyard dimensions shall be as indicated in Table 1 & Figure 3.

Table 1 – Outdoor HV Substation and Switchyard Dimensions (in meters)

Voltage	A	B	C	D	E	F	G	H
69 kV	4.3	4.0	2.8	1.6	4.9	1.3	15.3	4.6
115 kV	7.4	4.0	3.1	4.9	4.9	2.5	15.3	4.6
230 kV	9.1	6.2	5.0	4.9	6	3.1	19	4.6

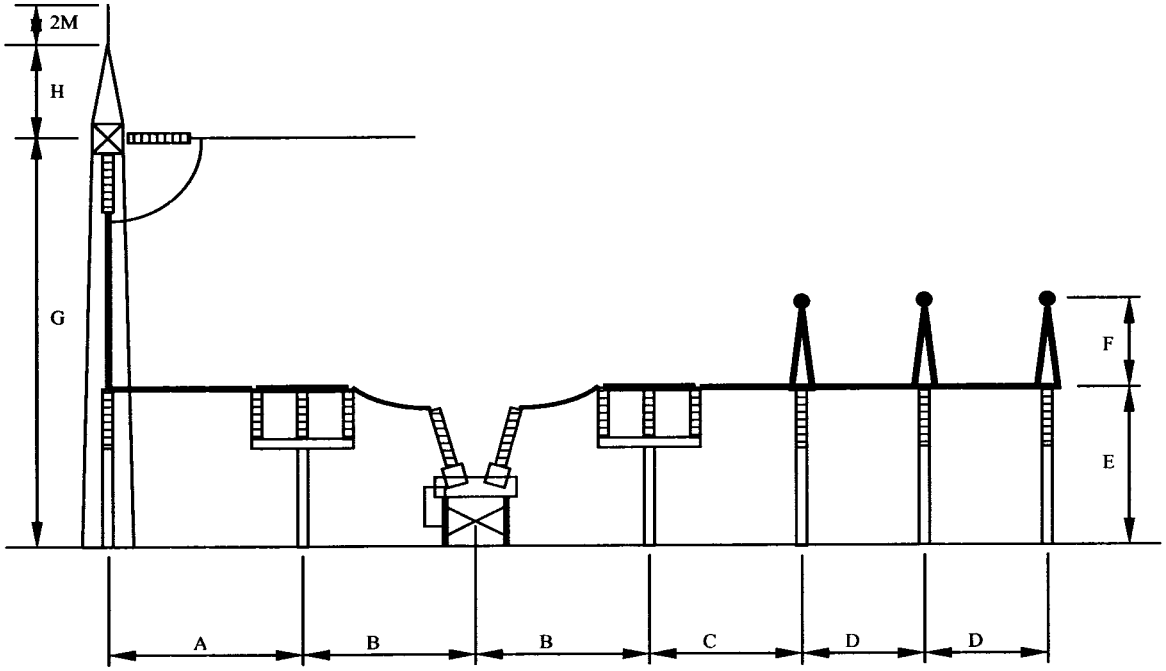

Figure 3 – Outdoor Substation Dimension

7.10 Exposed equipment insulators, except for surge arresters, shall have a minimum leakage distance of 40 mm per kV line-to-line of the nominal system voltage.

7.11 Surge arresters shall have the following characteristics:

a) Be of the composite insulation type with silicone rubber compound external insulation over a hermetically sealed fiberglass core.

b) The voltage rating of arresters used in substations shall be as indicated in Table 2.

c) On systems with nominal operating voltages of 13.8 kV and above, surge arresters shall be installed in substations at the following locations:

i) At interface points between overhead lines, open bus and underground lines

ii) On power transformer terminals which are connected to overhead lines or open bus.

iii) When specified as being required, intermediate class arresters shall be used for transformers rated 10 MVA and below and station class arresters shall be used to protect transformers rated greater than 10 MVA.

Commentary Note 7.11:

Ratings in the table are based on solidly grounded systems which is the Saudi Aramco standard for these nominal system voltages. Ungrounded or resistance grounded systems require higher arrester ratings. MCOV is "Maximum Continuous Operating Voltage".

Table 2 – Required Arrester Ratings vs. System Voltages

Nominal System Voltage (kV)	Maximum System Voltage Rating (kV)	Duty Cycle Rating (kV rms)	MCOV (kV rms)
34.5	38	30	24.4
69	76	60	48.0
115	127	108	84.0
230	253	192	152.0

d) Surge arrester grounding terminals shall be connected, with minimum bends, directly to the ground bus or grid or, in the case of surge arresters mounted on transformers, directly to the grounding pad provided on the transformer.

8 Substation Bus Configurations

The section defines the mandatory requirements for selecting and configuring bus designs in substations for both offshore and onshore.

Commentary Note:

Final selection between acceptable alternatives in below table will be based on Life-Cycle Cost analysis covering several factors based on requirements, criticality, redundancy, number of incoming and outgoing circuits, economics, maintenance and operation cost, etc.

Acceptable Bus Configurations

Bus Configuration (G4)	Receiving Bus (G1)				Primary Distribution Bus (G2)				Secondary Bus (G3)			
	Outdoor L1		Indoor L4		Outdoor		Indoor L4		Outdoor		Indoor L3	
Breaker & half (L10)	No		**Yes**		No		No		No		No	
Double Bus, Single Breaker (L8)	No		**Yes**		No		**Yes**		No		No	
Ring Bus(L7)	**Yes**		**Yes**		**Yes**		**Yes**		No		No	
Sectionalized Radial (L9)	No		No		**Yes**	L1 L6	**Yes**	L6 E1	No		**Yes**	L5
Radial	No		No	E2	**Yes**	L2	No	E2	No		**Yes**	L5

Notes:

General:

G1 "*Receiving Bus*". Used to receive and deliver bulk power to transformers in a primary substation. This includes equipment operating at a **nominal** voltage of 69 kV and above and equipment delivering power to a captive transformer feeding a single motor.

G2 "*Primary Distribution Bus*". Delivers power to the primary of the transformers feeding the "*secondary*" substations. This includes equipment operating at a **nominal** voltage of 13.8 kV and above and equipment delivering power to a captive transformer feeding a single motor.

G3 "*Secondary Bus*". Substation distributing or feeding power to the **utilization** equipment. This includes equipment operating at **nominal** voltages of 13.8 kV and below.

G4 Refer to SABP-P-034 for detailed description of bus configurations and design considerations.

Limitations:

L1 "*Outdoor*" substations consisting of 16-SAMSS-508 breakers and open, uninsulated bus system. Not acceptable for offshore substations, or onshore substations within 5 km of the coast

L2 "*Outdoor*" substations consisting of 16-SAMSS-510 manually operated pad mounted switchgear.

L3 "*Indoor*" substation consisting of 16-SAMSS-504 metal-clad and 16-SAMSS-502 metal enclosed switchgear.

L4 "*Indoor*" substation consisting of Gas-Insulated switchgear (GIS).

L5 Refer to SAES-P-116 as to when simple radial and sectionalized radial configurations should be used and breaker positions during normal operation.

L6 Inverted PI configuration. Shall be limited to two (2) primary and two (2) secondary feeders. No breakers shall be installed in the secondary feeders. It is acceptable to operate the bus coupler Normally Closed.

L7 Ring bus shall be limited to a maximum of four (4) positions. Spare breakers shall not be installed. Redundant generation sources and redundant utility sources shall not be connected to adjacent positions.

L8 Shall only be used for **major substations**. Spare bay breakers shall not be installed. Layout shall accommodate future addition of necessary breakers to complete bay configuration.

Bus Sectionalized/Coupler Configuration:

-228 configuration. Two (2) sectionalizers, two (2) couplers and eight (8) disconnectors: if fed with both SEC and co-generation feeds

-216 configuration. Two (2) sectionalizers, one (1) coupler and six (6) disconnectors: if fed with only SEC feeds.

Bus sectionalizer and bus coupler shall be operated Normally Closed. Redundant feeders or redundant power sources shall not be connected to the same bus segment or connected to the bus segments connected by the bus coupler. Refer SABP-P-034 for one-line representation.

L9 Bus coupler (i.e., bus tie breaker) shall operate Normally Open. Redundant secondary feeders shall not be connected to the same bus segment.

L10 Shall only be used for **major substations** with both SEC and co-generation feeds**.** Spare bay breakers shall not be installed. Layout shall accommodate future addition of necessary breakers to complete bay configuration. Redundant generation sources and redundant utility sources shall be connected in separate bays and shall not be connected to adjacent positions in the separate bays.

Exceptions: E1 For equipment operating at 34.5 kV, 16-SAMSS-504 switchgear is acceptable.

E2 Acceptable for offshore substations or onshore substations feeding gas/oil production wellsites.

Revision Summary

5 November 2012 Major revision.