Engineering Standard

SAES-P-100 28 February 2005

Basic Power System Design Criteria

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1 Scope

This SAES prescribes mandatory requirements for the design and installation of electrical power systems. This SAES is intended to assist engineers and designers in those areas not specifically referenced in other Saudi Aramco SAESs, SAMSSs, etc. 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 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 form SA 6409-ENG 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

The following is a list of Mandatory Saudi Aramco Engineering Requirements (MSAERs) which are specifically related to the design, specification, and installation of electrical power systems and equipment. In addition, other MSAERs for related disciplines shall be used in conjunction with those listed below as required.

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-008	*Restrictions to Use of Cellars, Pits, and Trenches*
SAES-B-017	*Fire Water System Design*
SAES-B-009	*Fire Protection & Safety Requirements for Offshore Production Facilities*
SAES-B-055	*Plant Layout*
SAES-B-068	*Electrical Area Classification*
SAES-J-902	*Electrical Systems for Instrumentation*
SAES-K-001	*Heating, Ventilating and Air Conditioning (HVAC)*
SAES-P-101	*Regulated Vendor List – for Electrical Equipment*
SAES-P-103	*Batteries and U.P.S. Systems*
SAES-P-104	*Wiring Methods and Materials*
SAES-P-107	*Overhead Distribution Systems*
SAES-P-111	*Grounding*
SAES-P-113	*Motors and Generators*
SAES-P-114	*Power System and Equipment Protection*
SAES-P-116	*Switchgear and Control Equipment*
SAES-P-119	*Onshore Substations*
SAES-P-121	*Transformers, Reactors, Voltage Regulators*
SAES-P-123	*Lighting*
SAES-P-126	*Power Monitoring System*

Saudi Aramco Materials System Specifications

14-SAMSS-531	*Power Transformers*
14-SAMSS-533	*Three-Phase Dry-Type Power Transformers*
14-SAMSS-534	*Overhead-Type Distribution Transformers*
14-SAMSS-536	*Pad-Mounted, Three-Phase Distribution Transformers*
14-SAMSS-600	*Material, Manufacture, and Preservation of Wood Poles*

14-SAMSS-602	*Material, Manufacture & Preservative Treatment of Wood Crossarms*
15-SAMSS-502	*Medium Voltage Power Cables, 5 kV through 35 kV*
15-SAMSS-503	*Submarine Power Cable 5 kV through 115 kV*
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-507	*High Voltage Motor Controller – Outdoor*
16-SAMSS-508	*SF6 Gas Insulated Circuit Breakers, Outdoor – 34.5 kV through 230 kV*
16-SAMSS-510	*Manually Operated Pad Mounted SF6 Switchgear: 1 kV to 36 kV*
16-SAMSS-511	*Metal-Enclosed Bus Indoor and Outdoor*

(Note that SAES-P-116 prohibits the use of bus duct in new installations)

16-SAMSS-512	*Outdoor Switchrack – Low Voltage*
16-SAMSS-514	*Control and protective Relay Panel – Indoor*
16-SAMSS-517	*Adjustable Frequency Drive System – 1 kV and Above*
16-SAMSS-518	*Low Voltage Panel Boards*
16-SAMSS-519	*Indoor Switchboard - Low Voltage*
16-SAMSS-520	*Cablebus*
16-SAMSS-521	*Indoor Automatic Transfer Switch – Low Voltage*
17-SAMSS-502	*Form-Wound Induction Motors 250 HP and Above*
17-SAMSS-503	*Severe Duty Totally Enclosed Squirrel Cage Induction Motors to 250 HP*
17-SAMSS-510	*Synchronous Generators*
17-SAMSS-511	*Stationary Storage Batteries*
17-SAMSS-514	*Battery Chargers*

17-SAMSS-515	*Auxiliary Electrical Systems for Skid-Mounted Equipment*
17-SAMSS-516	*Uninterruptible Power Supply System*
17-SAMSS-518	*Diesel Generator Set*
17-SAMSS-520	*Form Wound Brushless Synchronous Motors*

Saudi Aramco Standard Drawings

AE-036014	*Pole Setting (2 Sheets)*
AA-036015	*Double Deadend End Structure Pole Installation Details*
AD-036016	*Bonding Details, Armless Construction, Angle Structure, 60 to 90 Degrees*
AC-036021	*Armless Construction, Angle Structure, 15 to 30 Degrees, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036022	*Armless Construction, Angle Structure, 60 to 90 Degrees, 2.4, 4.16, 13.8, and 34.5 kV*
AD-036023	*Guy and Anchors, Down Guys (3 Sheets)*
AA-036025	*Four-Way Manhole (2 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 and Anchors Power Installed Screw*
AD-036066	*Guy and Anchors, Overhead Guy (3 Sheets)*
AD-036070	*Rock Anchor Installation*
AC-036079	*Armless Construction, Tangent Structure, 0 to 2 Degrees, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036085	*Armless Construction, Angle Structure, 0 to 15 Degrees, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036102	*Armless Construction, Angle Structure, 30 to 60 Degrees, 2.4, 4.16, 13.8, and 34.5 kV*
AC-036104	*Armless Construction, Full Dead-end 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	*Three-Phase Cable Termination, Overhead Armless to Underground (2 sheets)*
AD-036133	*Pole Top Switch Grounding Detail*
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AD-036136	*Bonding Details, Armless Construction, Angle Structure, 30 to 60 Degrees*
AA-036259	*Airstrip Lighting Layout*
AB-036273	*Surface Marker Underground Electric Cable*
AB-036319	*Standard Sign "DANGER HIGH VOLTAGE KEEP AWAY"*
AB-036326	*Standard Sign: Underground Electric Cable*
AB-036387	*Tank Grounding*
AA-036390 (Sheet 1)	*Tangent Pole with Tap-Off Transformer Installation*
AA-036390 (Sheet 2)	*Dead-End/Tap-Off Pole with Transformer Installation*
AB-036398	*Details - Street Lighting*
AA-036572	*Grounding Arrangement for Disconnect Switch Structure*
AB-036745	*Lighting Pole, Tapered Seamless Aluminum 3M for Security Fence*
AB-036760 (Sheet 1)	*Perimeter & Area Lighting, Typical Layout, Part of Plant Area (SSD/13, SAES-O-113)*
AB-036760 (Sheet 2)	*Elementary Diagram Power & Control Circuits for Security Lighting per SSD/13, SAES-O-113*
AB-036766	*Standard Electrical Symbols One-Line Diagram (Power) (Sheets 1 to 3)*
AB-036766 (Sheet 4)	*Standard Electrical Symbols - Plan Layout*
AD-036874	*Installation of Direct Buried Electric Cable and Conduit*

Saudi Aramco Form and Data Sheet

SA Form 6409-ENG *Request for Waiver of Saudi Aramco Engineering Requirement*

Saudi Aramco General Instruction

GI-0002.717 *Procedures and Guidelines for Handling Polychlorinated Biphenyls (PCB's)*

4 Definitions

Approval: Written approval of the **ESD Coordinator**.

Base Voltage: The bus voltage calculated by starting with the **nominal voltage** at the swing bus and calculated for each bus based on the transformer turns ratios.

Bus Tie Breaker: A breaker used to connect the two busses of **secondary-selective** system**.**

Captive Transformer: A transformer whose output is dedicated to a single piece of **utilization equipment**.

Controlgear: Equipment manufactured to either 16-SAMSS-503 (Low Voltage Controlgear), 16-SAMSS-506 (High Voltage Controlgear) or 16-SAMSS-507 (High Voltage Motor Controller - Outdoor).

Critical Loads: Are loads:

a) Where a single contingency failure could cause a loss of power which would create an immediate hazard to human life or cause a significant reduction in Saudi Aramco total production, or

b) Which cannot be shut-down for a minimum of five consecutive days annually for scheduled maintenance on upstream power supply equipment.

Examples of critical loads are: major computer centers, critical care areas in clinics and hospitals, major office buildings, process units in major gas plants, major GOSPs, and process units in refineries.

Demand: Electrical load averaged over a specified time period.

ESD Coordinator: Coordinator, Electrical Systems Division, Consulting Services Department.

High Voltage: Voltages 1000 V or greater unless otherwise designated in a specific MSAER or referenced international standard.

Commentary Note:

*The term **medium voltage** is no longer being used in most North American and essentially all European (IEC) standards. Where used, it generally refers to system voltages greater than 1 kV but less than 100 kV. As used in Saudi Aramco, **medium voltage** generally refers to voltages 2.4 kV and above but less than 34.5 kV.*

Industrial Facilities: Refer to SAES-P-116 for definition.

Low Voltage: Voltages less than 1000 V, unless otherwise designated in a specific MSAER or referenced international standard.

MSAER: Mandatory Saudi Aramco Engineering Requirements.

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

Nominal Voltage: Refer to Table 1.

Operating Load:

a) For new facilities**:** Anticipated one-hour **demand** based on plant or facility design conditions.

b) For existing facilities: When data from metering equipment is available: Maximum 60-minute **demand** measured over a minimum of one year.

Commentary Note:

Depending on the nature of the loads, the operating load may be substantially less than the total connected load.

PCB free: Containing less than 1 ppm Polychlorinated biphenyl.

SAMSS: Saudi Aramco Materials System Specification.

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). These schemes are standardized. Refer to SAES-P-116 for standardized schemes.

Secondary-selective Substation: A substation fed by two independent power sources (different transmission or distribution lines) which consists of one or more sets of two transformers and associated **secondary-selective switchgear**. Also referred to as a "double-ended" substation.

Severe Corrosive Environment: As described in Section 9 of this standard.

Switchgear: Equipment manufactured to either 16-SAMSS-502 (Low Voltage Switchgear) or 16-SAMSS-504 (High Voltage Switchgear).

Switchrack: Equipment manufactured per 16-SAMSS-512.

UPS: Uninteruptible Power Supply.

Utilization device/equipment: Equipment whose primary function is to convert electrical energy to another form or store electrical energy. Examples of utilization equipment would be motors, heaters, lamps, batteries, etc. Equipment directly feeding/controlling the utilization equipment is considered part of the utilization equipment (e.g., AFDs, reduced voltage starters, battery chargers, etc.).

5 General

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

5.2 Basic Design Codes

Electrical power systems shall be designed and constructed in accordance with the latest edition of NFPA 70 (National Electrical Code) and ANSI C2 (National Electrical Safety Code), as supplemented or modified by the Saudi Aramco Engineering Standards.

5.3 **Low voltage** AC distribution systems shall be protected by circuit breakers. Fuses shall not be used.

Exception:

Molded case circuit breakers with integral current limiting fuses are permitted and fuses are permitted for protection of circuits fed from UPS systems.

5.4 All interrupting devices shall be fully rated for the short circuit duty. Refer to SAES-P-116 for additional details and exceptions.

Commentary Note:

This means, for example, that designs based upon series-rated or cascade-rated equipment shall not be used.

5.5 Only **secondary-selective switchgear** shall be used to feed **critical loads**.

Exception:

*Critical facilities or equipment fed from a single-ended substation bus which has a standby generator capable of automatically supplying the required power to the bus within 10 seconds after a power failure are permitted with **approval.***

Commentary Note:

Secondary selective switchgear configurations have been standardized. Refer to SAES-P-116 for details of the standarized schemes.

5.6 Electrical equipment for firepump installations shall meet the requirements of NFPA 20 except as modified by the following **MSAER**s:

SAES-B-009	*Fire Protection & Safety Requirements for Offshore Production Facilities*
SAES-B-017	*Fire Water System Design*
SAES-P-116	*Switchgear and Control Equipment*

5.7 Existing equipment containing PCB shall be handled in accordance with GI-0002.717. Insulating materials, insulating liquids, etc., in new equipment shall be PCB-free.

5.8 Interfaces with communications systems shall be in accordance with SAES-T-Series.

5.9 Refer to SAES-P-116 for clearance around out door pad-mounted equipment. (e.g., Pad-mounted distribution transformers, pad-mounted switchgear, etc.).

5.10 "Approval" or "authority having jurisdiction" issues contained with the NEC (i.e., NFPA 70) shall be referred to the Consulting Services Department / Electrical Systems Division for resolution.

6 Design Basis

6.1 System Voltage and Frequency

6.1.1 The frequency of alternating current electrical power systems shall be 60 Hz.

Exception:

*Existing facilities with 50 Hz. power systems (including 50 Hz. systems with **nominal voltages** which do not comply with Table 1) and additions, replacements, etc., to these systems that do not result in a requirement to add 50 Hz. generation capacity, are permitted.*

6.1.2 The primary distribution within **industrial facilities** shall be 13.8 kV, three-phase, three-wire. Secondary distribution shall be either 4160V, three phase, three wire and/or 480V, three phase three wire.

Commentary Note:

*SAES-P-116 prohibits 480 V **switchgear** or **controlgear** in **industrial facilities** to be derived from a 4160 V system.*

6.1.3 The following describes the nominal system voltage and grounding which shall be used at the respective voltage listed in Table 1.

Table 1 – Nominal Voltage Levels

Nominal Voltage	Phase	Wire	Type Grounding
120/240	Single	Three Wire	Solid
208Y/120	Three	Four Wire	Solid
480	Three	Three Wire	Solid
480	Three	Three Wire	High Resistance (See Note 3)
480Y/277 (See Note 8)	Three	Four Wire	Solid
4,160	Three	Three Wire	Low Resistance
13,800	Three	Three Wire	Low Resistance
69,000	Three	Three Wire	Solid
115,000	Three	Three Wire	Solid
230,000	Three	Three Wire	Solid

Notes:

1. Existing ungrounded systems and existing systems with different voltage levels (e.g., 2.4 kV) are not required to be changed retroactively.
2. Additions or extensions to existing systems with different voltage levels that increase the MVA capacity of the system is not permitted. The exception is if the new or replacement equipment has a dual voltage rating with a voltage level in Table 1.
3. See SAES-P-111 for restrictions and approvals required for high resistance grounding.
4. Steady-state service and utilization voltage ranges shall be per Voltage Range A, ANSI C84.1 for the above nominal voltages. For Saudi Aramco installations, the service voltage is defined as the voltage at the secondary of a supply transformer having a primary voltage of more than 600 volts.
5. See SAES-P-111 for specific system grounding requirements and for grounding requirements for special applications such as downhole pump motors.
6. SEC nominal distribution voltages may be used on the **high voltage** side of transformers fed directly from a SEC distribution system.
7. These nominal system voltage requirements do not apply to **captive transformers** in specialty applications such as supplying submersible pump motors and high voltage adjustable frequency drive applications. Voltages for **captive transformer** applications shall be reviewed by the **ESD Coordinator**.
8. 480/277 is acceptable at sub-distribution levels for lighting only.(for example, distribution transformer to panelboards feeding lighting). Saudi Aramco material specifications prohibit 480/277V ratings for **low voltage swithgear** and **controlgear**.

6.2 Steady state voltage range, under all study conditions, shall be as follows:

6.2.1 **Low Voltage** Systems

i) At branch circuit/distribution equipment connection points (e.g., **switchgear**, **controlgear**, panelboards, **switchracks**, etc.): 95% to 105% of **nominal voltage**.

ii) At light fixtures: 91.7% to 104.2% of **nominal voltage**.

iii) At **utilization equipment** other than lights: 90% to 104.2% of **nominal voltage**.

6.2.2 **High Voltage** Systems

i) At branch circuit/distribution equipment connection points (e.g., **switchgear**, **controlgear**, etc.): 97.5% to 105% of **nominal voltage**.

ii) At the utilization device: 90% to 104.2% of **nominal voltage**.

6.3 Voltage Drop associated with Motor Starting

6.3.1 When a motor is started, the voltage at every **utilization device**, anywhere in the electrical system, shall not drop below 85% of the **nominal voltage**.

6.3.2 When a motor is started, the voltage at the terminals of the motor being started shall not drop below 85% of the rated motor voltage.

Exceptions:

*For **high voltage** motors, when approved and documented by the motor manufacturer, a drop to 80% of rated motor voltage is permitted at the terminals of the motor being started.*

For electric submersible pumps in oil or production water service, steady state and motor starting voltage drops for motor branch circuits and at motor terminals of shall meet recommendations of API 11S3, "Recommended Practice for Electric Submersible Pump Installations."

6.4 Direct Current Systems

Maximum total voltage drop for main, feeder, and branch circuits shall not exceed 5%. The average voltage drop in branch circuits shall not exceed 2% with a maximum of 4% at the most distant load.

7 System Studies

System studies are required for new facilities and major additions to existing facilities. If uncertain whether the additions to existing facilities are "major", contact the **ESD Coordinator**.

7.1 The following studies shall be performed to verify proper design of the electrical power systems and equipment:

7.1.1 Load-flow.

7.1.2 Short-circuit.

7.1.3 Motor-starting.

The Electrical Transient Analyzer Program (ETAP) Power Station (Windows version) shall be used to conduct the above studies. Input and output data files shall be furnished to the facility proponent's engineering organization and to Consulting Services Department.

Commentary Note:

For major additions to existing facilities, the system study and performance requirements apply to new and existing facilities. For example, if motors are being installed in an existing plant, the motor starting study requirement and results apply to the existing motors.

7.2 Additionally, the studies indicated below shall be performed on a case-by-case basis. The **ESD Coordinator** should be contacted early enough in the project cycle to assist in determining the need to conduct these studies, the criteria for the analysis, and the simulation tool to use.

7.2.1 Transient Stability: For facilities with generation greater than 10MW, and for all offshore power generation.

7.2.2 Harmonic Analysis: If a non-linear load (e.g., AFD, Power Convertors, etc.) is added to the power system with a rating that is a significant portion of the facility capacity.

Commentary Note:

The IEEE-519 standard will be the basis for the harmonic studies. With HV AFDs, the AFD manufacturer is responsible to provide harmonic mitigation. Refer to 16-SAMSS-517 for details.

7.2.3 Switching Transient Analysis: If supply is significantly affected by induced capacitive switching transients (e.g., shunt capacitor banks or lengthy HV cables).

The definition of "significant" is highly application specific. Contact the Saudi Aramco/Consulting Services Department/Electrical Systems Division if clarification is needed.

7.3 Actual system data and constraints shall be used for all studies.

7.4 Unless the actual impedance of a transformer is known from the transformer tests, 7.5% transformer impedance tolerance shall be used so that the specified design impedance is increased by 7.5% for load flow and motor starting calculations and decreased by 7.5% for short circuit calculations.

7.5 For motor-starting studies, maximum source impedance shall be used in calculating voltage drops. Motor starting studies shall be performed with all other motors running at normal load.

7.6 Maximum system voltage levels shall be determined assuming all motor loads are disconnected and in the case of **secondary-selective substations** that both transformers are operational and the **bus tie breaker** is in its normal state.

7.7 Normal system voltage levels shall be based upon **operating load.**

7.8 Minimum voltage of each circuit shall be based on the normal **operating load** plus the **operating load** of the largest spare (standby) motor if the spare motor is not interlocked to prevent starting while the primary motor is running. Minimum voltages down stream of **secondary-selective substations** supplying **utilization devices** shall be calculated assuming that one transformer is out of service and the **bus tie breaker** is closed.

7.9 For short circuit studies, the maximum ultimate 3-phase short circuit fault-current shall be used with a pre-fault voltage of 102% of the bus **base voltage**. Short circuit studies for **secondary-selective substations** with normally open **bus tie breakers** shall be evaluated assuming that one incomer breaker is open and the **bus tie breaker** is closed (i.e., one transformer is supplying the entire load.)

7.10 For new transformer installations, transformer off-load tap settings shall be assumed to be at the mid-point (neutral position). For analysis of existing systems, actual transformer off-load tap settings shall be used. For analysis of load additions to existing systems, transformer off-load tap settings at either extreme of the tap changer operating range shall not be used.

Exception:

When calculating minimum voltage levels, it is acceptable to assume that the off-load transformer taps can be set one step off the neutral position. In this case, all studies shall use the same transformer tap position.

7.11 For **switchgear** fed by transformers with on-load tap changers, it is acceptable that the load flow studies assume that these tap changers will automatically regulate the voltage on the secondary **switchgear** bus, directly connected to these transformers, to the **nominal voltage**.

7.12 Sizing of the electrical system shall be based upon using 110% of the sum of the **operating load** plus all known future loads.

7.13 **UPS** distribution systems design shall also ensure that short-circuits, anywhere in the system, that drops the **nominal voltage** at any **utilization device**, or **utilization device** distribution equipment upstream of the short circuit location to less than 90%, shall be cleared within (four) 4 milliseconds.

8 Electrical Area Classification Design

8.1 Hazardous area classification shall be in accordance with the requirements of SAES-B-068.

8.2 In hazardous (classified) areas, equipment that is required by the National Electrical Code (NEC) to be approved shall be labeled or listed or certified by any of the agencies listed in Table 2 below.

Table 2 – Certification Agencies for Equipment in Hazardous Areas

USA	Underwriters Laboratories, Inc. (UL)	Labeled or listed
USA/Canada	Intertek Testing Services (ITSNA) **Note**: Formerly known as ETL.	Labeled or listed
USA	National Recognized Testing Laboratory	Certified
USA	Factory Mutual Research Corp. (FM)	Certified
Canada	Canadian Standards Association (CSA)	Certified
UK	Electrical Equipment Certification Service (EECS) **Note:** EECS operates the BASEEFA certification scheme	Certified
Belgium	Institute National des Industries Extractives (INIEX)	Certified
France	Laboratoire Central des Industries Electriques (LCIE)	Certified
Germany	Physikalisch Technische Bundesanstalt (PTB)	Certified
Italy	Centro Elettrotechnico Sperimentale Italiano (CESI)	Certified
Netherlands	KEMA Nederland B.V. (KEMA)	Certified
Australia	Quality Assurance Services (QAS) **Note:** QAS is a subsidiary of Standards Australia	Certified

8.3 Installations in hazardous locations shall be per the National Electrical Code, with the following additions and exceptions:

8.3.1 EEx or Ex marked equipment certified or approved by one of the agencies listed in Table 2 is acceptable. Class and Zone markings are not required on EEx or Ex marked equipment but method of protection must be marked and must correspond with NEC Article 505

requirements for suitable protection method(s) for the hazardous area where the equipment is applied.

8.3.2 Equipment suitable for Class 1, Zone 0 locations may be used in Class 1, Division 1 locations.

8.3.3 Increased safety (protection type "e") motors and terminal boxes are not permitted in Zone 1 locations.

Commentary Note:

The "e" protection method is acceptable if it is used in combination with the "d" protection method, if d" is the primary protection method.

8.3.4 Flameproof enclosures EEx d II are permitted in Class I, Division 1 locations as meeting the NEC requirements for approved enclosures, provided:

i) NEC requirements for cable entry are met;

ii) the overall enclosure is flameproof EEx d II (explosion-proof) as a whole (not only its components);

iii) the enclosure is constructed of a conductive metal or has an integral metal bonding device that ensures a positive low-resistance bond between conduits or/and cable armors entering or terminating at the enclosure; and

iv) if used outdoors, the enclosure is rated a minimum of IP54.

8.3.5 The equipment selection, approval and labeling requirements in the NEC for Division 2 installations also apply to Zone 2 installations.

9 Environmental Conditions

9.1 The following locations shall be deemed as "severe corrosive environments" for the purposes of selection of electrical equipment:

9.1.1 Outdoor offshore locations

9.1.2 Outdoor onshore locations within one kilometer from the shoreline of the Arabian Gulf

9.1.3 Outdoor onshore locations within three kilometers from the shoreline of the Red Sea.

9.1.4 All of the Ras Tanura Refinery and Terminal.

9.2 Electrical equipment shall be rated in accordance with the requirements of the SAES-P or SAMSS specific to the equipment and its installation. When not covered in these documents:

9.2.1 For ambient temperature:

The temperature criteria shown in Table 3 shall be used to establish equipment rating.

9.2.2 For other environmental data refer to SAES-A-112.

Table 3 – Temperature Criteria

Location	Ambient Temperature	
	Average Monthly Normal Maximum (°C)	Maximum Daily Peak (°C)
Outdoors (Air)	45	50
Earth (Soil)	40	40
Ocean (Water)	30	30
Indoors in Well-Ventilated Buildings	40	50
Indoors in Air-Conditioned Buildings	See Note 1 below	See Note 1 below
Non-ventilated Enclosures Exposed to the Sun	56 See Note 2 below	56 See Note 2 below

Notes:

1. Per the design temperature of the air conditioning system (See SAES-K-001) or 30°C, whichever is greater.

   Commentary Note:

   Stationary storage batteries are normally rated for operation in 25°C ambient. See SAES-P-103 for battery rating and ambient temperature requirements and SAES-K-001 for battery room design temperature requirements.

2. "Effective" ambient temperature inside an equipment enclosure due to combined effects of a 45°C ambient outside the enclosure, 8°C rise from solar radiation, and an assumed 3°C rise caused by an internal heater or other heat producing device.

10 Protection Systems

10.1 Protection requirements for specific equipment is covered within the applicable **SAMSS** to which the equipment is connected.

10.2 Refer to SAES-P-114 for general protection requirements (e.g., relay coordination study criteria).

Revision Summary

29 September 2004 Major revision.
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