Engineering Standard

SAES-X-300 31 May, 2003

Cathodic Protection of Marine Structures

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Saudi Aramco DeskTop Standards

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1 Scope

1.1 This standard prescribes the minimum mandatory requirements governing the design and installation of cathodic protection for both offshore and shore side sections of marine structures exposed to soil, seabed, or seawater environments. The standard applies to both coated and uncoated structures.

1.2 Typical marine structures include but are not limited to the following:

Pumping Platforms	Sea Islands
Auxiliary Platforms	Breasting Dolphins
Utility Platforms	Trestles
Metering Platforms	Flare Support Structures
Mooring Dolphins	Break Waters
Tie-in Platforms	Pipe Supports
Gas/Oil Separator Platforms (GOSP)	Loading/Mooring Buoys
Living Quarter Platforms	Piers
Gas Compression Platforms	Sheet Piling
Well Platforms	Wharves
Pipelines	Single Point Mooring (SPM)
Pipeline Markers	

1.3 This standard may not be attached to or made a part of purchase orders.

2 Conflicts and Deviations

2.1 Resolve 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 in writing, with the Company or Buyer Representative through the Manager, Consulting Services Department (CSD) of Saudi Aramco, Dhahran.

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 such requests to the Manager, CSD of Saudi Aramco, Dhahran.

3 References

Referenced standards and specifications shall be the latest edition, revision or addendum unless otherwise stated.

The Desktop TIC and the Saudi Aramco Engineering Standards intranet web site contain the latest revisions of all standards and a listing of standard drawings. The Drawing Management System (DMS) contains standard drawing listings with the latest revision numbers. These standard drawings can also be accessed through the web enabled DMS QVP system at http://engdwg.aramco.com.sa.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*
SAEP-332	*Cathodic Protection Commissioning*
SAEP-333	*Cathodic Protection Monitoring*

Saudi Aramco Engineering Standards

SAES-P-104	*Wiring Methods and Materials*
SAES-X-400	*Cathodic Protection of Buried Pipelines*
SAES-X-600	*Cathodic Protection of Plant Facilities*

Saudi Aramco Materials System Specifications

17-SAMSS-004	*Tap Adjustable Rectifiers for Cathodic Protection*
17-SAMSS-006	*Galvanic Anodes for Cathodic Protection*
17-SAMSS-007	*Impressed Current Anodes for Cathodic Protection*
17-SAMSS-008	*Junction Boxes for Cathodic Protection*
17-SAMSS-012	*Modular Photovoltaic Power Supply for Cathodic Protection*
17-SAMSS-017	*Impressed Current Cathodic Protection Cables*

Saudi Aramco General Instructions

GI-0002.710	*Mechanical Completion and Performance Acceptance of Facilities*
GI-0428.001	*Cathodic Protection Responsibilities*

Saudi Aramco Standard Drawings

The following Saudi Aramco Standard Drawings outline specific methods of designing and installing cathodic protection systems.

AB-036008	*Mixed Metal Oxide Anode for Offshore Pile Mounted Anode*
AA-036108	*Offshore Negative Terminal Junction Box*
AD-036132	*Termination Detail Cable Identification*
AA-036276	*Multi-Purpose Junction Box Details*
AA-036304	*Offshore Pile Mounted Anodes*
AA-036335	*Half Shell Bracelet Type Anode for Pipe Sizes 4-60 Inch*
AA-036348	*Galvanic and Impressed Anodes on Offshore Structures*
AA-036350	*2 Terminal Bond Box*
AA-036378	*Rectifier Installation Details (Sheets 1 & 2)*
AB-036381	*Thermite Welding of Cables to Pipelines & Structures*
AA-036384	*Offshore Anode Junction Box*
AA-036389	*Galvanic Anodes Details*
AD-036763	*Offshore PLIDCO Sleeve Anode*
AA-036780	*Offshore Tension Spring and Rope Impressed Current System*
AD-036785	*Symbols for Cathodic Protection*
AB-036907	*Cathodic Protection Test Stations for Buried Pipelines*

Saudi Aramco Library Drawing

DA-950035	*Offshore Rectifier Installation Details (Sheet 1)*

3.2 Industry Codes and Standards

National Association of Corrosion Engineer (NACE)

National Fire Protection Association

NFPA 70	*National Electrical Code (NEC)*

4 Design

4.1 Design Review and Approval

4.1.1 It is mandatory that proposed construction drawings and the related cathodic protection design information for every design package be submitted to the Proponent cathodic protection organization and the Cathodic Protection & Coatings Unit of CSD for review and approval.

The design agency shall not issue drawings for construction that have not been approved in writing by the Proponent cathodic protection organization and the Cathodic Protection & Coatings Unit of CSD.

4.1.2 The Supervisor of CSD/ME&CCD/Cathodic Protection and Coatings Unit and the Supervisor of the Proponent cathodic protection organization shall indicate the completion of their review and approval of each Cathodic Protection drawing by signature. The signatures shall be placed in the "Review of Key Drawings" block of each Index X drawing. Alternatively, a list containing all approved project drawing numbers can be signed by the Supervisor of CSD/ME&CCD/Cathodic Protection and Coatings Unit and the Supervisor of the Proponent cathodic protection organization to indicate their review and approval.

4.1.3 The design package submitted for review shall contain at minimum:

a) The scope of work

b) Professionally drafted full size Index "X" CP drawings that:

- Detail each CP item by description and stock number if applicable
- Detail the proposed location for each piece of CP equipment including but not limited to rectifiers, anodes, junction boxes and test stations
- Detail and specifically identify all cathodic protection cables including all anode, structure, bond, and rectifier cables
- Clearly identify the specific and individual cable routing and termination points within the respective junction boxes, bond boxes, and rectifiers
- Detail all cathodic protection equipment using the cathodic protection symbols shown on Standard Drawing AD-036785 "Symbols for Cathodic Protection"

c) All calculations and applicable field data required to verify design compliance with Saudi Aramco Cathodic Protection Engineering Standards.

d) CP equipment details.

4.2 Design General

4.2.1 Provide cathodic protection for all submerged and buried metallic marine structures, equipment and pipelines using galvanic anode systems, impressed current anode systems, or a combination of an impressed current and galvanic anode system.

4.2.2 Install an impressed current system where AC power is available. Use the anticipated costs over a 25 year period or the expected life of the structure, whichever is greater, to evaluate the economic justification for installation of AC power for an impressed current CP system. The estimated cost for future repairs shall be considered in the economic justification in areas where historical data and associated repair costs for external corrosion related failures is available.

4.2.3 Install the CP equipment that is required for monitoring protected structures per SAEP-333, in accessible unobstructed locations.

4.2.4 Bond offshore structures at appropriate locations to ensure complete electrical continuity.

4.2.5 Cathodically protect both submerged sections and buried sections of subsea pipelines that terminate inside onshore facilities, or up to the isolation flange for the onshore-offshore transition. Protect the submerged sections with bracelet galvanic anodes according to Standard Drawing AA-036335. For buried sections of subsea pipelines, refer to SAES-X-400 or SAES-X-600, as applicable.

4.3 Design Life

Minimum design life for the cathodic protection systems shall be as follows:

a) Galvanic anodes only: 25 years

b) Galvanic anodes if accompanied by an impressed current system: 5 years

c) Impressed current anodes: 20 years

4.4 Current Density Criteria

4.4.1 The system design shall provide the minimum current densities detailed in Table 1.

Table 1 – Current Density Criteria for Design

	Current Density (mA/m^2)	
Environment	**Coated Structure [1], [3]**	**Uncoated Structure**
Seawater [2]	10	50
Mud or Soil	10	20

Notes:

(1) Coated structures do not include coated pipelines. Provide cathodic protection to coated subsea pipelines using bracelet galvanic anodes according to Standard Drawing AA-036335.

(2) Higher current densities may be required depending on water turbulence and/or velocity.

(3) The total current requirement for protecting coated well casings and platforms without an impressed current cathodic protection system, shall be calculated using the current densities for uncoated structures and well casings to a depth of 750 meters.

4.4.2 Impressed Current CP systems for offshore platforms shall provide sufficient current for all submerged surface areas, including the total submerged and buried surface area of the piles, well casings, conductors, plus all submerged and buried sections of other structures associated with the platforms. The design for the cathodic protection system for electrified platforms with well casings shall provide 25 amperes for each well casing in addition to the current required for the surfaces of the platform structure that are submerged and below the mudline.

4.4.3 Galvanic Anode CP systems for offshore platforms shall provide adequate current for all submerged surface areas, plus:

- the surface areas of the well casings extending to a depth of 750 meters below the seabed,
- the buried surface area of the piles and conductors, and
- all submerged and buried sections of other structures associated with the platform.

4.4.4 The submerged structure surface area is defined as a total area extending from the base of the structure to Lowest Astronomical Tide (LAT) level.

4.5 Protection Criteria

The cathodic protection system shall achieve a minimum structure-to-water potential of negative 0.90 volt with reference to a silver/silver chloride electrode. For buried onshore portions of marine structures, it is required to achieve negative structure-to-soil potentials between 1.0 volt and 3.0 volts with reference to a copper-copper sulfate electrode over the entire structure.

4.6 Anodes

4.6.1 Galvanic Anodes

Use galvanic anodes that comply with the appropriate sections of 17-SAMSS-006. Table 2 shows the recommended design parameters for galvanic anode materials.

Table 2 – Design Parameters for Galvanic Anode Materials

Anode Material	Consumption Rate (kg/A-Y)	Open Circuit Potential (-mV) (1)
Aluminum	3.7	1050
Magnesium	7.7	1650
Zinc	11.8	1050

Note:

(1) Measured with reference to a silver/silver chloride reference electrode.

4.6.2 Impressed Current Anodes

4.6.2.1 Use one of the following impressed current anode materials, according to specification 17-SAMSS-007:

a) Platinized Niobium (Pt/Nb)

b) Mixed Metal Oxide (MMO)

c) High Silicon Cast Iron (HSCI) for shoreline area only

4.6.2.2 Refer to Table 3 for the recommended design parameters for the approved impressed current anode materials.

4.6.2.3 If various types of impressed current anode material are used on a structure, connect only anodes of the same material to any one rectifier.

Table 3 – Design Parameters for Impressed Current Anode Materials

Anode Material	Consumption (kg/A-Y)	Current Density Maximum (mA/cm^2)	Voltage Maximum (volt)
HSCI	0.45	0.7	No Limit
MMO	See Note 1	60.0	No Limit
Pt/Nb	8.63x10-6	40.0	60

Note:

(1) Use the consumption rate specified by the manufacturer of the MMO element, to determine the current output capacity and design life of MMO anodes.

4.7 DC Power Source

4.7.1 Manufacture rectifiers and photovoltaic systems according to 17-SAMSS-004 and 17-SAMSS-012 respectively, and install them in accordance with Saudi Aramco Library Drawing DA-950035 sheet 1, or Saudi Aramco Standard Drawing AA-036378 sheet 1 and 2. Use oil immersed rectifiers (type OA) for all outdoor applications, and air cooled rectifiers (type AA) for indoor applications.

4.7.2 DC power supplies shall have a maximum rated output voltage of no greater than 100 volts. The sizing of the rectifier shall be optimized and based on the overall circuit resistance. Rectifier sizes other than those listed in SAMSS category 17 can be used, but must be approved by the Supervisor of the Cathodic Protection and Coatings Unit of CSD.

4.8 Cables

DC cables connected to the rectifier shall be AWG #4 (25 mm^2) or larger. Size the cables according to the National Fire Protection Association NFPA 70, National Electrical Code (NEC). See 17-SAMSS-017 for details of approved cathodic protection cables. Use Table 310-16, Column for 90°C rated cables of the latest NEC Handbook to calculate the ampacity of HMWPE cables, and consider an ambient temperature of 40°C. Cable terminations shall comply with standard drawing AD-036132.

4.9 Monitoring Facilities

For the onshore portions of marine pipelines, provide test stations for measuring pipe-to-soil potentials at insulated cased crossings, paved road crossings and other locations outside the SSD fence and plant fence as required by operational needs. Use Standard Drawing AB-036907 as a reference for the design and construction of the test station.

4.10 Bonding

4.10.1 Effective cathodic protection design of the marine facilities requires complete electrical continuity of the structures. Bonding shall be installed to ensure complete electrical continuity throughout a marine structure. Install steel bond bars or 70 mm² (2/0 AWG) bond cables to ensure electrical continuity between all well casings and between the well casings and the platform. Provide bonding for J-tubes, boat landings, riser guards or other submerged mechanical fittings that are not welded.

4.10.2 Platforms with impressed current CP shall have a dedicated negative lead wire to each well casing. Use a negative junction box (AA-036108) to terminate multiple negative leads. Junction and bond boxes used in cathodic protection systems for marine structures shall comply with the design and construction required by 17-SAMSS-008.

4.10.3 Use flexible straps or cables to electrically bond walkways connecting two adjacent platforms at both ends of the walkway. Provide at least two bonds at each end, and the bond cable size shall not be less than No. 2/0 AWG.

4.11 Electrical Isolation

4.11.1 Do not use isolating devices on offshore structures.

4.11.2 Do not use isolating devices on submerged or buried portions of pipelines.

4.11.3 Provide aboveground electrical isolating devices to isolate pipelines at the onshore-offshore transition.

4.11.4 Install a 2-terminal bond box at each isolating device in an accessible location. The bond box design and construction shall comply with Standard Drawing AA-036350.

5 Installation

5.1 Anodes

5.1.1 Install all anodes according to the latest revisions of Standard Drawing Nos. AB-036008, AA-036304, AA-036335, AA-036348, AA-036389, AD-036763 and AA-036780.

5.1.2 Just before installing the anodes, the contractor shall conduct an insulation resistance test between all armor wires twisted together and

the central copper conductor. The test shall use a Megger type instrument set at 5000 volts and shall be witnessed by the Proponent Operation Inspection Unit or Projects Inspection. If the measured resistance is less than one mega-ohm, reject the entire anode/cable assembly.

5.1.3 Use a rope or sling instead of the anode cables to lift or lower the anodes. If the cable becomes "kinked" or the armor is "birdcaged", reject the anode and cable assembly. Bend the cables with care to avoid damage. The radius of the curve of the inner edge of any bend shall not be less than five times the diameter of the cable.

5.1.4 Install jacket mounted impressed current anodes only after the jacket is in place, insertion piles have been driven and grouted, and power for the impressed current CP system is available.

5.1.5 Terminate impressed current anode cables for offshore cathodic protection systems at anode junction boxes located on platform decks. The anode junction boxes shall be manufactured in accordance with 17-SAMSS-008 and Standard Drawing AA-036384. Connect positive header cables from anode junction boxes to rectifiers or to other positive junction boxes in accordance with Standard Drawing AA-036276.

5.2 DC Power Source

5.2.1 Rectifier mounting locations shall be in non-hazardous areas whenever practical.

5.2.2 Provide AC power input to the rectifier through a fused disconnect switch or circuit breaker. Enclose the device in a NEMA 4X or 7, if applicable, enclosure with an operable handle mechanism. Refer to SAES-P-104 for enclosure NEMA rating requirements. Mount the device in an accessible location approximately 1.8 meters above grade and within 3 meters of the rectifier. Select the circuit breaker rating for the nearest commercially available size for 125% of the rectifier input current at rated load.

5.2.3 Install the rectifier per the respective construction drawings.

5.2.4 Open the rectifier cover and clean the exposed components to ensure that they are free of sand or dust, and fill the rectifier with insulating oil.

5.3 DC Cables

5.3.1 Thermite weld all cable connections to steel pipes and structures according to Standard Drawing AB-036381. Do not thermite weld on stainless steel.

5.3.2 Repair of anodes or anode cables is not permitted.

5.4 Bond Boxes and Junction Boxes

5.4.1 Show all bond boxes and junction boxes on construction drawings. Locate the junction boxes on the cellar deck walkway level or any conveniently accessible deck. The junction box access cover shall face inward, and be accessible without scaffolding or ladders. Identify all cables inside bond boxes and junction boxes with a permanent and durable tag according to Standard Drawing AD-036132. Properly label the cables and the terminals to designate the anodes or the structures to which they are connected.

5.4.2 Provide an outside nameplate on all junction and bond boxes to identify the structure and/or the rectifier unit to which they are connected. When required by the Proponent Organization, engrave a location schematic on the nameplate of positive and negative junction boxes.

5.4.3 Locate junction boxes in non-hazardous areas whenever practical.

5.4.4 Junction box material for non-hazardous areas shall either be stainless steel (Type 304 or 316) or UV resistant non-metallic material per 17-SAMSS-008.

5.4.5 Junction boxes for Class I Division 2 hazardous locations shall be explosion proof (NEMA 7/4X) enclosures approved for Class I locations. However, general-purpose enclosures, NEMA 4 or 4X, shall be acceptable, if the selection of all current shunts is such that the power dissipation rating of any individual shunt would not exceed 2.5 watts under normal operating conditions at rated load. If a general-purpose enclosure is used, provide particular care and attention to sizing, tightening, and regular maintenance of the mechanical connections of the conductors in the enclosure.

6 Commissioning and Inspection

6.1 Commissioning

Perform all pre-commissioning and commissioning in accordance with GI-0002.710 and SAEP-332, Cathodic Protection Commissioning.

6.2 Energize all impressed current anodes within 30 days of installation.

6.3 Rectifier system pre-commissioning and/or commissioning shall be performed by a qualified individual in the presence of cathodic protection personnel from the Proponent Department in accordance with SAEP-332 and GI-0002.710.

6.4 Follow the guidelines of Saudi Aramco Library Drawing DA-950035, Sheet 1, and Saudi Aramco Standard Drawing AB-036381, to bond all well casings together at surface sections, and to the platform within 30 days of completion of the drilling of the well.

6.5 Inspection

Notify Project Inspection and the Proponent Operations Inspection Unit at least four days prior to the start of construction to ensure that inspection coverage can be provided for the complete duration of the job. Provide full inspection during anode installation, cable installation, and positive and negative cable hookups to rectifier. Submit test data sheets to the inspection agency for review.

7 Records

Revise all construction drawings to show the "as-built" system. The as-built drawings shall show the type and location of cathodic protection equipment. The Company Representative shall submit copies of the as-built drawings to the cathodic protection Proponent Organization defined by GI-0428.001 for review within sixty days of project completion. Corrections shall be completed within thirty days and resubmitted.

Revision Summary

31 May, 2003 Major revision.