Materials System Specification

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Submarine Pipe Weight Coating

Document Responsibility: Offshore Structures Standards Committee

Saudi Aramco DeskTop Standards

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1 Scope

This specification covers the concrete weight coating requirements for line pipe used underwater where additional mass must be added to compensate for buoyancy. It is intended to provide specifications for weight coating single pipe joints prior to incorporation into a pipeline. This Specification does not cover requirements for the line pipe nor does it include requirements for internal or pipe external corrosion coatings (see Section 4 "Definitions").

2 Conflicts and Deviations

2.1 Any conflicts between this specification and other applicable Saudi Aramco Materials System Specifications (SAMSSs), Engineering Standards (SAESs), Standard Drawings (SASDs), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer's Representative through the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

2.2 Direct all requests to deviate from this specification in writing to the Company or Buyer's representative, who shall follow internal company procedure SAEP-302 and forward such requests to the Manager, Consulting Services Department of Saudi Aramco, Dhahran.

3 References

Material or equipment supplied to this specification shall comply with the latest edition of the references listed below, unless otherwise noted.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirement*
SAEP-361	*Storage, Handling and Installation of Weight Coated Pipe*

Saudi Aramco Materials System Specification

09-SAMSS-088	*Aggregates for Concrete*

Saudi Aramco Engineering Standards

SAES-H-002	*Internal and External Coatings for Steel pipelines and Piping*

SAES-H-101	*Approved Protective Coatings Systems for Industrial Plants & equipment*
SAES-H-200	*Storage, Handling and Installation of Externally Coated Pipe*
SAES-L-850	*Design of Submarine Pipelines and Risers*
SAES-Q-001	*Criteria for design and Construction of Concrete Structures*

Saudi Aramco Inspection Requirements

Form 175-012800	*Concrete Weight Coating; for Line Pipe Used Underwater*

Saudi Aramco Standard Drawings

AA-036335	*Cathodic Protection, Half Shell Bracelet Type Anode for Pipe Sizes 4" - 60"*
AB-036381	*Thermite Welding of Cables to Pipelines and Structures*

3.2 Industry Codes and Standards

American Concrete Institute

ACI 207.3R	*Practice for Evaluation of Concrete in Existing Massive Structures for Service Conditions*
ACI 318M	*Building Code Requirement for Reinforced Concrete*

American Society for Testing and Materials

ASTM A810 - 94	*Standard Specification for Zinc-Coated (Galvanized) Steel Pipe Winding Mesh*
ASTM C150 - 94	*Standard Specification for Portland Cement*
ASTM C39	*Standard Test Method for Compressive Strength of Cylindrical Concrete*
ASTM C642	*Standard Test Method for Density, Absorption and Voids in Hardened Concrete*

American Association of State Highways and Transportation Officials

AASHTO T26	*Quality of Water to be used in Concrete*

4 Definitions

Anti-Slip Adhesive: is a bonding agent applied to the pipe external corrosion coating prior to the application of the concrete weight coating to improve the bond between the concrete and the coatings. The adhesive, if used, is part of this specification.

Concrete Weight Coating: is a reinforced concrete outer layer applied to the pipe to provide additional mass to ensure sufficient negative buoyancy. This type of coating is part of this specification.

Crack Initiators: are circumferential incisions in the concrete weight coating that are made at regular intervals along the pipe to control the localized extent and direction of cracking (primarily during pipe laying) in the concrete weight coating. Crack initiators, if required, are part of this specification.

Pipe External Corrosion Coating: is a protective coating (such as fusion bonded epoxy) applied to the bare pipe, see SAES-H-002. This type of coating is not part of this specification.

5 Materials

5.1 Pipe to be Weight Coated

Pipe shall be supplied as specified in the Purchase Order. This Specification assumes that the pipe external corrosion coating has been applied prior to weight coating.

5.2 Damaged Pipe

Title for all pipe received in a damaged condition shall remain with the pipe supplier until repaired and accepted by the Buyer's Representative. The Vendor shall be responsible for repair of any damage to pipe and coating occurring during offloading or during any subsequent handling until loaded for shipment. Prior to weight coating, any defect must be removed and repaired by the Vendor, as directed by and to the satisfaction of the Buyer's Representative. In general, pipe should not be weight coated if it has not been accepted by the Buyer's Representative.

5.3 Coating Systems

Separate coating systems required on the bare pipe are:

a. Pipe External Corrosion Coating (not covered by this Spec.)

b. Concrete Weight Coating (covered by this Spec.)

5.4 Identification

Each pipe joint shall be marked with a reference number and the day, month and year of weight coating unless otherwise specified in the Purchase Order. Reference numbers shall be painted on the outside of the weight coating and shall be a minimum of 50 mm (2 in) in height.

6 Concrete Weight Coating

6.1 Application

The concrete weight coating shall be placed directly on the pipe external corrosion coating (with anti-slip adhesive).

6.2 Reinforcing of the concrete weight coating shall be as detailed below. Woven or welded galvanized wire mesh shall be spirally-applied simultaneously with the concrete coating with a mesh overlap of 25 mm (1 in) minimum. Reinforcing shall be covered by a minimum of 25 mm (1 in) of concrete for concrete thickness equal to or greater than 50 mm (2 in) and shall be generally equally spaced through the thickness of the concrete weight coating.

The minimum reinforcing wire sizes and design numbers for the concrete weight coating shall be in accordance with ASTM A810 - 94 for the indicated weight coating ranges:

- 25 mm to 50 mm (1 to 2 in): Single wrap of 1.37 mm (0.054 in), Design No. 107- ½ x 1-½ x 17 or No. 607- ½ x 1-½ x 17, galvanized woven hexagonal mesh. Woven mesh shall be applied spirally and placed within the middle of the concrete coating.
- 54 mm to 76 mm (2.125 to 3 in): Single wrap of 2 mm (0.079 in), Design No. 2.00 x 1.60, galvanized welded wire mesh, crimped in the middle between the cross wires.
- 79 mm to 114 mm (3.110 to 4.5 in): Double wrap of 2 mm (0.079 in), Design No. 2.00 x 1.60, galvanized welded wire mesh, crimped in the middle between the cross wires.
- 117 mm (4.610 in) and greater: A minimum of 3 wraps of galvanized welded wire mesh, crimped in the middle between the cross wires shall be used. The line wire of the mesh shall not be less than 3 mm (0.125 in), and the cross wire not less than 2 mm (0.079 in).

6.3 Concrete design mix shall be approved by the Buyer's Representative prior to coating. As a minimum, the concrete mix shall meet the following requirements:

1. Cement shall be ASTM C150 - 94, type V (Sulfate resistant Portland cement).

2. The dry density of the concrete shall be as specified in the Purchase Order but not less than 190 pcf and should be tested in accordance to ASTM C642.

3. The concrete shall achieve a 28-days design compressive strength of 27.6 MPa (4000 psi) minimum, in accordance with ASTM C39.

4. Water absorption should be 5% maximum.

5. Water cement ratio should be 0.4 maximum.

6. Aggregates shall consist of one or more of: natural sand, manufactured sand, iron ore. It must conform to requirements of 09-SAMSS-088 relating to fine aggregates, except abrasion and soundness tests shall not be required.

   If coarse aggregates are used, grading shall comply with 09-SAMSS-088, Size number 7 or 8.

   If iron Ore is used, the grading shall comply with 09-SAMSS-088, except for the percentage passing #200, sieve shall not exceed 15%.

7. Cement mill test certificates shall be provided for each shipment of cement. Under no circumstances shall the source of cement be changed without prior written approval of the Buyer.

8. If bagged cement is used, all bags shall be plainly marked with the name of the manufacturer, type of cement and volume. Similar information shall be provided in the bills of lading accompanying each shipment of bulk cement.

6.4 Anti-slip adhesive shall be required if the pipe is FBE coated. Technical data sheets details of the anti-slip adhesive shall be submitted to the Buyer's Representative.

6.5 Mixing water shall be free from oils, acids, organic matter or other deleterious substances and shall satisfy the requirements listed in Table A of this specification. Testing for total dissolved solids (TDS) shall be performed in accordance with AASHTO T26. A complete geochemical water analysis shall be submitted to the Buyer's Representative for approval prior to the start of production and shall be required for each new water source chosen. No change in water source shall be permitted without prior approval by the Buyer's Representative.

Table A – Acceptance Criteria for Mixing Water

Test	Frequency of Test	Maximum	Minimum
TDS for mixing	Weekly	500 ppm	N/A
TDS for curing	Weekly	1000 ppm	N/A
pH	Weekly	8.0	6.0

6.6 Concrete Weight Coating Application procedure shall be submitted to the Buyer's Representative for approval. The Weight Coating shall be a continuous, even, uniform layer over the entire length of each pipe joint except for 300 to 380 mm (12 to 15 in) of the pipe at each end. These end portions of the pipe (referred to as Cutback) shall be left uncoated to allow field welding. Alternative cutback dimensions may be specified in the Purchase Order for special welding conditions. When the external pipe corrosion coating is fusion bonded epoxy (FBE), the concrete weight coating shall be applied by the Compression Coat method. When the Compression Coat method is used, the cutback edges of the concrete coating shall be covered with bituminous coating APCS-10 in accordance to SAES-H-101 to protect the ends of the reinforcing mesh from corrosion.

6.7 Crack Initiators shall be used for concrete weight coating thickness above 100 mm (4 in) or as indicated in the Purchase Order. Crack initiators shall be spaced approximately one meter (3 ft) apart and shall not be less than one meter (3 ft) from the cutback. Crack initiation shall be by crack inducers placed prior to weight coating or by water slotting or saw cutting following weight coating. Crack inducers shall be lengths of triangular cross section plastic resin installed as continuous rings. Water slotting or saw cutting grooves shall be from 20 mm to 25 mm (3/4 to 1 in) deep and from 6 mm to 15 mm (1/4 to 5/8 in) wide. Groove dimensions may be different than specified provided that calculations show that concrete edges at the grooves do not touch under all construction and in-service conditions.

6.8 Anode Installation. The Vendor shall be responsible for the installation of bracelet type anodes supplied by the Buyer if specified in the Purchase Order.

The bracelet anode(s) shall be installed at the center of the pipe and in accordance with Standard Drawings AA-036335 and AB-036381 as applicable. Concrete weight coating shall finish a maximum of 130 mm (5 in) at either side of bracelet anode(s). Installation shall be directed by and to the satisfaction of the Buyer's Representative. If the concrete coating is applied prior to anode installation, the Vendor shall leave an uncoated area at the center of the pipe joint to allow for the installation of the bracelet anode(s). Dimensions of the uncoated area shall be supplied to the Vendor by the Buyer's Representative if required.

6.9 Curing of concrete shall be in accordance with SAES-Q-001.

6.10 Thickness of the Concrete Weight Coating shall be determined on the basis of the density of the concrete. The thickness shall be such that the mass of the weight coating over the length of each joint of pipe shall comply with the required negative buoyancy specified in SAES-L-850. Weight coating thickness shall not be less than 25 mm (1 in). Each joint of pipe shall be weighed as it is removed from the coating machine and the weight must be acceptable to the Buyer's Representative.

Acceptable weight coating mass variation is +25% for concrete thickness less than 45 mm (1-¾ in), +15% for concrete thickness between 45 and 57 mm (1-¾ and 2-¼ in), and +10% for concrete thickness greater than 57 mm (2-¼ in).

Acceptable weight coating thickness variation is +8 mm (5/16 in).

No mass or thickness shall be less than specified. Buyer shall have authority to approve individual pipe joints exceeding these tolerances as long as the quantity does not exceed 2% of the total number of pipe joints ordered.

6.11 Cleaning of pipe ends and anodes must be performed to the satisfaction of the Buyer's Representative before a joint of coated pipe is considered acceptable.

6.12 Patching of all voids or cracks which do not otherwise constitute a reject of the joint of weight coated pipe must be accomplished to the satisfaction of the Buyer's Representative. The concrete in the immediate area must be removed back to sound concrete and a repair made by the shotcreting technique or other method(s) acceptable to the Buyer's Representative. Any visible gaps or lack of bond between concrete and external pipe coating must be cut back to the point of complete circumferential bond and patched as above. Gaps which extend over the entire length of a joint of weight coated pipe shall be cause for rejection and shall necessitate stripping and re-application of the weight coating of the entire pipe joint.

6.13 For qualification of new plants or when changing the concrete mix design the following tests should be performed as a minimum:

1. Impact Resistance Test

   Pipe should be subjected to horizontal blows pendicular to pipe axis with a one ton hammer, striking at 2 m/ sec at any randomly selected location.

   Acceptance criterion:

   - Concrete thickness up to and include 50 mm:

15 blows (minimum) to expose the reinforcement and 30 blows (minimum) to expose coating.

- Thickness more than 50 mm:

  30 blows (minimum) to expose the reinforcement and 90 blows (minimum) to expose coating.

2. Shear Resistance Test

   Pipe should be subjected to 30 KN/ m^2 (4.4 psi) (pull or push) for three hours, after that increase stress gradually at a rate of 2 KN/ m^2 (0.3 psi) until slippage between concrete and the steel is initiated.

   Acceptance criterion:

   - Failure at 60 KN/ m^2 (8.8 psi) (minimum).

7 Handling

Weight coated pipe storage and handling shall be in accordance with SAEP-361.

Stacking and shipping of weight coated pipe may commence at any age when the compressive strength exceeds 13.8 MPa (2000 psi). Stacking shall conform to the requirements of SAES-H-200 except that in no case shall the weight coated pipe be stacked higher than the following:

Nominal Pipe Diam. (in.)	Number of Layers
12 and less	10
14-16	7
18-20	6
22-24	5
26-36	4
38-42	3
44 and more	2 only

The weight-coated pipe shall be handled and stacked carefully to prevent damage to the coating. Methods of pipe handling proposed by the Vendor shall be submitted to the Buyer's Representative for approval.

Rubber strips, 150 mm wide by 12 mm thick (6 x ½ in), shall be placed between pipes at quarter points.

8 Quality and Inspection Requirements

8.1 Inspection Requirements

The items manufactured to this specification are subject to verification by the Buyer's Representative per Saudi Aramco Inspection Requirement Form 175-012800.

Failure to meet the requirements described therein shall be cause for rejection and shall necessitate stripping and re-coating. Should there be deviations from this Specification affecting a total number of pipe joints representing ten percent (10%) or more of the Purchase Order, then the entire Purchase Order shall be rejected. All corrections or repairs to the Purchase Order shall be submitted to the Buyer's Representative for approval, and accepted as satisfactory, prior to shipment. The Buyer reserves the right to obtain samples, of either the delivered product or its constituent components, whichever he deems necessary, to verify compliance of the Purchase Order with any of the requirements stated in this specification.

8.2 Compressive strength of the concrete shall be determined in accordance with ASTM C39. The 28 days strength shall exceed 27.6 MPa (4000 psi). The 7 or 28 day test may provide acceptance for compressive strength only, if the strength exceeds 27.6 MPa (4000 psi).

If, in the opinion/judgment of the Buyer's Representative, the strength of concrete weight coating after 28 days on any one particular joint is suspect, sample cores may be taken from the joint and tested in accordance with ACI 318M, Sec. 5.6.4 and ACI 207.3R, Chapter 5 or ACI 318M, Chapter 20 at the option of the Buyer.

If, after testing the sample core, the joint is accepted, core holes shall be patched by the Vendor in accordance with Paragraph 6.12 above.

Revision Summary

16 February 2009	Revised the "Next Planned Update." Reaffirmed the contents of the document, and reissued with minor revisions.
21 August 2010	Minor revision.