Requirements for Procurement of Pipeline Anodes

Engineering Services, L.P. 832-418-9180

Table of Contents

1.0 Introduction 3
2.0 Materials 3
3.0 Anode design 4
4.0 Tolerances 5
5.0 Anode fabrication 5
6.0 Inspection of anodes 7
7.0 Marking and handling 8
8.0 Documentation 8

Engineering Services, L.P. 832-418-9180

1.0 INTRODUCTION

This Specification covers the minimum requirements for the design, manufacture, testing and supply of Pipeline Anodes suitable for the cathodic protection of subsea pipeline systems as detailed hereunder.

1.2 Detail Design

The Supplier shall be responsible for all aspects of the Anode detail design and production of fabrication drawings. These items shall be formulated, based on information provided by COMPANY. All supplier design calculations and drawings shall be submitted to COMPANY for approval, at least 21 days, and prior to production commencing

2.0 MATERIALS

2.1 Anode Material

2.1.1 The sacrificial anode material shall be an aluminium or aluminium-zinc-indium type alloy, which shall be designed in accordance with the requirements of Appendix 1.

2.1.2 The chemical composition of the alloy shall be in accordance with the following requirements:

Element	Weight Content			
	Zinc Anodes		Aluminium Anodes	
	Min %	Max %	Min %	Max %
Iron (Fe)	-	0.005	-	0.10
Silicon (Si)	-	0.125	0.08	0.21
Copper (Cu)	-	0.005	-	0.006
Zinc (Zn)	remainder		2.8	6.25
Indium (In)	-	-	0.01	0.03
Titanium (Ti)	-	-	-	0.05
Cadmium (Cd)	0.025	0.070	-	-
Palladium (Pd)	-	0.006	-	-
Others (each)	-	0.10	-	0.02
Aluminium (Al)	0.10	0.50	remainder	

2.1.3 The chemical composition of each furnace melt shall be determined by spectrographic analysis of representative samples taken at the beginning and end of each melt. The quantity of all specified elements shall be determined.

No additions shall be made to the melt between a spectrographic analysis yielding results within specification, and commencement of pouring.

2.1.4 Each melt shall be assigned a unique melt number which shall be transferred to all samples taken from that melt, all anodes cast from that melt, and all records pertaining to that melt.

2.1.5 All samples shall be retained by the Supplier for a minimum of 1 year

Engineering Services 82-418-9180

beyond completion of the anode supply and may, at the option of COMPANY, be required to be made available for independent analysis.

2.1.6 Records on each melt chemical analysis shall be prepared for review by COMPANY.

One sample of material cast shall be tested to confirm the electrochemical capacity of the anode material when coupled with steel, is as specified in Clause 2.1.1. The test procedure shall be in accordance with DnV RP B401 Clause 4.7, and shall be subject to Company review. A test sample 30 mm in length and diameter shall be acceptable.

2.1.7 Anode casting shall not commence until after verification that the melt chemical analysis is within the specified limits.

2.1.8 Calibration records for chemical analysis equipment shall be submitted to the Company for review during production of anodes.

2.2 Anode Insert Materials

2.2.1 The inserts shall be fabricated from weldable structural steel plate / sections.

2.2.2 Ladle analyses shall show that the carbon equivalent (CE) of insert materials shall not exceed 0.38% as determined as follows :

$$CE = C + \frac{Mn}{6}$$

Where each element symbol represents its percentage content.

2.2.3 Mill Certificates for steel insert materials shall be supplied in accordance with BS EN 10204 3.1b.

2.3 Connection Cables

2.3.1 The electrical cable used to connect the anode to the pipe shall be 16 mm², single core copper, PVC (7/1.70 mm).

2.3.2 Following welding of the cable lug to the anode core, the brazed cable connection shall be tested for strength by pulling the cable with the weight of the body in the direction of lay of the cable.

2.3.3 An electrical continuity test of the cable connections between the free cable end and the anode core shall give a resistance of not more than 0.01 ohms.

2.4 Anode Coating Material

2.4.1 The coating material for the anode internal surfaces shall be coal tar epoxy paint. Details of the material shall be provided to COMPANY for review prior to use.

2.4.2 Manufacturer's certificates of compliance shall be supplied with each batch of material and retained by the Supplier for Company review.

3.0 ANODE DESIGN

3.1 Construction

3.1.1 Each anode shall comprise of two tapered half-cylindrical shells cast onto a welded steel cage insert.

3.1.2 The cage shall provide support for the anodic material throughout the design life.The half shells shall be attached round the pipe via bolts.

3.1.3 The steel cage insert shall be designed to achieve a minimum anode utilisation factor of 0.8.

3.2 Dimensions

3.2.1 The thickness and internal radius of the anode shall be as follows:-

3.2.2 The length of the anode shall be

Engineering Services, L.P. 832-418-9180

determined by the Supplier to take into account the tapered ends. The resulting length shall be sufficient to achieve the specified net weight of anode material. Anode net weight is defined as total anode weight, measured before attachment of connecting cables, minus the weight of the steel cage insert.

3.2.3 All anode dimensions shall be within the tolerances set out in Section 4.0 of this Specification.

3.3 Cable Connection to Pipe

3.3.1 Each anode half is to be provided with two continuity straps to facilitate electrical connection to the pipe. Each cable shall be a minimum of 500 mm long.

3.3.2 The method of attachment of the cables to the steel cage insert shall be by means of a mild steel lug brazed to the cable end and welded to the anode cage. They shall be located so as not to interfere with assembly and welding of the completed anode.

3.4 Drawings

3.4.1 The Supplier shall prepare detailed dimensioned fabrication drawings of the anode design for review and approval by COMPANY prior to commencement of production.

4.0 TOLERANCES

4.1 Anode Half Shell Dimensions

4.1.1 The actual length of each anode half shell shall be within +3.0%, -0.5% of the nominal length, and the thickness shall be within ±3 mm of the nominal value. Anodes with dimensions outside these tolerances shall be rejected.

4.1.2 The inner radius of the shell shall be within +1.5%, -0.0% of the nominal value.

4.2 Insert Dimensions and Position

4.2.1 The anode insert locations inside the half shell shall be within 5 mm of the nominal position with respect to anode length and angular location and within 3 mm of the nominal position with respect to anode depth (thickness). The 3 mm tolerance on insert depth position shall be applied to the average of 12 measurements taken from each anode sectioned in accordance with Section 6.5 hereunder. Individual cage bars shall not be more than +4 mm, -3 mm from their nominal position (positive measured in the increasing anode radius direction).

4.2.2 The anode lugs for bolts shall be within 2 mm of the nominal position with respect to anode depth (thickness). Anodes with lugs outside this tolerance shall be rejected.

4.3 Anode Weight

4.3.1 The net weight of individual half shells shall be within ± 3% of nominal net weight.

4.3.2 The net weight of the complete anode order shall be within -0%, +2% of the total nominal net weight for the anodes.

4.3.3 The average anode net weight for each load of anodes (not exceeding 22 tonnes total weight) shall meet the requirements of 4.3.2.

5.0 ANODE FABRICATION

5.1 Anode Fabrication Procedure

5.1.1 The Supplier shall provide a description of his anode fabrication procedure to COMPANY for review and approval. The description shall

Engineering Services, L.P. 832-413-9180

include the following :

- insert fabrication;
- preparation of insert for anode casting;
- anode material sampling and analysis methods;
- casting procedure;
- cable attachment procedure;
- anode marking and inspection procedure.

5.2 Fabrication of Inserts

5.2.1 The welding of steel inserts shall be in accordance with the requirements AWS D1.1 or a similar agreed welding standard.

5.2.2 Welding procedures and welders shall be qualified in accordance with the requirements of AWS D1.1 similar agreed welding standards.

5.2.3 Welds shall be visually inspected and checked for soundness by hammering.

5.3 Insert Preparation

5.3.1 No more than 12 hours before anode casting operations the steel inserts shall be blast cleaned to achieve a surface preparation quality complying with SIS 05 59 00 Sa 2½.

5.3.2 The steel inserts shall be clean, dry and free from blooming when the anode is cast.

5.4 Anode Castings

5.4.1 Shrinkage depressions and cavities shall not exceed 10% of the nominal anode depth.

5.4.2 The topping up of irregularities shall be allowed only if the additional material is fully fused to the bulk anodic material. A maximum surface roughness tolerance of 10 mm peak to trough shall be permitted for the topping up surface. Any roughness outside this limit shall be rectified by surface dressing.

5.4.3 The anode casting shall be generally free of non-metallic inclusions.

5.4.4 Longitudinal cracks shall not be permitted on external anode face. Longitudinal hairline cracks on internal bore of anode not in excess of 40 mm long immediately adjacent to the exposed steel core are permissible.

5.4.5 Cracks penetrating through the anode body shall cause the anode to be rejected.

5.4.6 Within the section of anodic material wholly supported by the insert, transverse cracks shall be permitted with a maximum width of 1 mm and a length not greater than 200 mm. Anodes with cracks outside this tolerance shall be rejected.

5.4.7 A maximum of 5 cracks per anode may be permitted. Small close cracks may be taken as one crack.

5.5 Anode Internal Coating

5.5.1 Upon completion of all casting and inspection and prior to packing for shipment, the internal surface of each anode half-shell shall be coated as set out in 5.5.2.

5.5.2 The internal circumference of each anode half-shell shall be wire brushed to remove any loose deposits and coated with 75-100 microns thickness of coal tar epoxy paint. If the treated anodes are to be handled before the paint has fully cured, precautions shall be taken to avoid contact with or contamination of the coating.

Engineering Services, L.P. 832-418-9180

6.0 INSPECTION OF ANODES

6.1 General

6.1.1 If, during inspection, the rejection rate for a certain type of defect exceeds 5%, COMPANY reserves the right to require the Supplier to implement quality control procedures to identify and eliminate the cause of the defect.

6.1.2 Current calibration certificates for all testing and weighing equipment shall be provided for COMPANY review prior to use of such equipment.

6.2 Anode Weight

6.2.1 At the start of casting of anodes, the Supplier shall determine the average weight of steel inserts from weighing of 20 steel insert units. Subject to agreement by COMPANY, the average steel insert weight so determined may be used as the basis for calculation of anode net weights, for the purposes of this Specification.

6.2.2 The total weight of each anode half shall be accurately determined and shall be within specified tolerances. The individual half shell weights shall be determined before attachment of connecting cables.

6.2.3 Detailed records of anode unit number, anode melt numbers and anode weights shall be maintained.

6.2.4 The net weight of the complete anode order shall be determined from the records and shall be within specified tolerances.

6.3 Dimensions

6.3.1 The first ten anode half shells shall be dimensionally checked by the Supplier for conformance with all drawings and all specified tolerances.

6.3.2 The internal diameters of all half shells shall be checked by the Supplier for conformance with the requirements of this Specification.

6.3.3 The position of all anode lug locations with respect to anode internal radius shall be checked by the Supplier for compliance with the specified tolerances.

6.4 Surface Irregularities on Anode Castings

6.4.1 The Supplier shall visually inspect each anode casting for any casting defects exceeding specified requirements.

6.5 Anode Internal Defects

6.5.1 Two anode half shells, per pipe size, selected by COMPANY from the first 20 produced shall be transversely sectioned by single cuts at each quarter length. Colour photographs of the sectioned face shall be taken and retained for record purposes. This test shall be repeated at a frequency of one sacrificial anode test, per 50 anodes, per anode size.

6.5.2 In the event that a sectioned anode fails to meet the specified requirements for internal defects, the batch of 20 shall be sub-divided into batches 10. A representative half shell shall be selected from each batch of 10 for sectioning and inspection. Providing the anode meets acceptance requirements for internal defects the respective batch of 10 shall be accepted.

6.5.3 If the anode fails to meet acceptance requirements the batch of 10 shall be rejected.

6.5.4 The frequency of sectioning shall remain at one half shell per batch of 10 until five successive sections from these batches are acceptable. Thereafter testing shall be conducted

Engineering Services, L.P. 832 418-9180

at a frequency of one sacrificial test per 50 anodes.

6.5.5 The cut faces, when examined visually without magnification, shall not contain:

- more than 4% of surface area porosity;
- more than 5% of the insert perimeter with voids adjacent;
- any individual pore in the outer 80% of anode section greater than 8 mm dimension or with an area greater than 25 mm²;
- any individual pore in the inner 20% of anode section area greater than 10 mm dimension with an area greater than 64 mm².

Pore dimensions shall be the major axis dimension of the void.

6.5.6 The location of the steel insert shall be dimensionally checked to ensure compliance with approved drawings and specified tolerances.

6.5.7 The Supplier shall replace anode half shells destroyed for anode internal examination under Clauses 6.5.1 and 6.5.2.

6.6 Anode Trial Fit

All anodes will be trial fitted onto the appropriate coated pipe, at the Manufacturer's (pipe will be supplied by COMPANY). Any anodes which do not fit, following this trial, will be rejected. Prior to anodes leaving factory then all anodes trial fitted will become a specific pair from then on.

7.0 MARKING AND HANDLING

7.1 Marking

7.1.1 Each anode half shall be die-stamped on the outside face with the following:

- Suppliers mark or name;
- individual anode half number;
- the number of the melt from which the anode was cast;
- the anode 'Type' as defined in the Contract;
- inspection stamp.

7.1.2 The format of the die-stamping shall be agreed with by COMPANY prior to use.

7.2 Handling

7.2.1 Handling and storage of the anodes shall be such that dimensions, surfaces and quality of the anodes do not suffer any alteration.

7.2.2 The Supplier shall take all necessary precautions to protect the lugs of the steel insert the continuity straps and connection cables against damage during handling and storage.

8.0 DOCUMENTATION

8.1 General

The Supplier shall provide all documentation to COMPANY for review as required by the contract, this Specification and other referenced Specifications or standards. Documents to be supplied with quotation will be considered to be for information only.

8.2 Initial Submissions

Prior to the start of Production Operations the Supplier shall provide the following documentation for review by COMPANY. Documentation shall include but not be limited to the

Engineering Services, L.P. 832-418-9180

following:

- Quality Plan;
- Reports giving chemical analyses for each melt of the anode material. All elements for which a specification limit is set shall be reported;
- Calibration records for chemical analysis equipment;
- Anode detailed drawing;
- Anode melt weight calculations;
- Fabrication procedure;
- Welding procedure;
- Visual dimensional inspection reports;
- Die stamping format;
- All other inspection certificates and reports required by the Specification;
- Details of the Supplier's Quality Control Personnel and Equipment;
- Evidence of quality review to ISO 9000 of internal system audits and correcting action request.

8.3 Final Submission

The Supplier shall provide COMPANY with a Data Book containing the following documentation prior to load-out of anodes from the Suppliers premises. Documentation shall include but not be limited to the following :

- Certificate of Conformance;
- All documentation and photographs generated as per this specification;
- Certificate of Anode Chemical Analysis and Weight (to 50049, 3.1b);
- Photographs of sectioned anodes;
- COMPANY Release Note;
- Completed Quality Plan.

All reports and inspection certificates shall be signed to signify compliance with the requirements of this Specification and shall be marked with:

- Suppliers name and location;
- Companys Contract and item number;
- Melt number;
- Anode number(s);

Engineering Services, L.P. 832-418-9180

APPENDIX 1

1.1 Anode Design Data

The following design data is available:-

Anode Type		Aluminium Bracelet Type
Seawater Resistivity		300 mOhms -m
Current Requirements (Water depths 100 - 300m)	initial	380 mA/m2
	mean	120 mA/m2
	Final	140 mA/m2
Current Requirements (Water depths > 300m)	initial	363 mA/m2
	mean	130 mA/m2
	Final	168 mA/m2
Current Capacity	Aluminium	1850 Ah / Kg
Coating Breakdown	Initial	98 %
	Mean	96 %
	Final	92 %
Utilisation factor		0.80
Max allowable anode weight		240 Kgs
Max allowable anode spacing		200 m

1.2 Pipeline Data

The pipeline data is as per the attached pipeline data sheets:-

Data Sht No	Description
FD-3549.00-6500-966-PPR-001	RG-2 : Gas Pipeline 10'' P-36 / PLAEM
FD-3549.00-6500-966-PPR-002	RG-1 : Gas Pipeline 6'' P-36 / FSO (P-47)
FD-3549.00-6500-966-PPR-003	RO-1 : Oil Pipeline 10'' P-36 / FSO (P-47)
FD-3549.00-6500-966-PPR-004	RO-2 : Oil Pipeline 10'' P-36 / FSO (P-47)
FD-3549.00-6500-966-PPR-005	RO-3 : Oil Pipeline 10'' P-36 / FSO (P-47)
FD-3544.00-6500-966-PPR-001	MSO-1 : Oil Pipeline 10'' P-40 / P-38
FD-3544.00-6500-966-PPR-002	MSO-2 : Oil Pipeline 10'' P-40 / P-38
FD-3544.00-6500-966-PPR-003	MSG-2 : Gas Pipeline 6'' P-40 / P-38
FD-3544.00-6500-966-PPR-004	MG-3 : Gas Pipeline 8'' P-37 / P26
FD-3544.00-6500-966-PPR-005	MSG-1 : Gas Pipeline 12'' P-40 / PNA1

1.3 System Design life

The System Design Life is 20 years

Engineering Services, L.P 832-418-9180