



Exploration & Production

GENERAL SPECIFICATION

CORROSION

GS COR 201

Supply of sacrificial anodes

02	09/03	Change of Group name and logo
01	10/02	Possibility of connection of anodes by cables
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1. Scope

The document defines the requirements regarding quality, inspection and guarantees to be met for the supply of sacrificial anodes for cathodic protection of offshore structures and/or containers.

The structures concerned are fixed structures (platforms, pipes, pile dolphins, landing stages, etc.), floating structures (buoys, barges, storage ships, etc.), and/or containers (tanks, vessels, exchangers).

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
EN 12495	Cathodic protection for fixed steel offshore structures
EN 13173	Cathodic protection for steel offshore floating structures
EN 13174	Cathodic protection of harbour installations
EN 12474	Cathodic protection of sea lines
ISO 13623	Petroleum and natural gas industries - Pipeline transportation system
BS 4515	Welding of steel pipelines on land and offshore
ISO 10474	Steel and steel products-inspection documents
ISO 1460	Metallic coatings. Hot dip galvanised coatings on ferrous materials. Gravimetric determination of the mass per unit area
ISO 8501-1	Pictorial surface preparation standards for painting steel surfaces
EN 287-1	Approval testing of welders - Fusion welding - Part 1: steel
EN 288	Specification and approvals of welding procedures for metallic materials

Professional Documents

Reference	Title
API 5 L	Specification for line pipe
NACE RP 0387	Metallurgical and inspection requirements for cast sacrificial anodes for offshore applications
NACE RP 0492	Metallurgical and inspection requirements for offshore pipeline bracelet anodes
NACE TM 0190	Impressed current test method for laboratory testing of aluminium anodes



Reference	Title
DNV RP-B401	Cathodic Protection Design
ASTM D 1141	Specification for substitute ocean water
ASTM A 283 grade C	Standard specification for low and intermediate tensile strength carbon steel plate
ASTM B 633	Standard specification for zinc (hot dip galvanised) coatings on iron and steel products
ASTM A 123	Standard specification for electrodeposited coatings of zinc on iron and steel

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS COR 100	Design of cathodic protection of offshore structures
GS COR 102	Design of cathodic protection of sealines by sacrificial anodes
GS COR 401	Installation of anodes on submerged pipelines
GS COR 410	
GS SPS 009	Corrosion protection of subsea equipment

3. Sacrificial alloys

3.1 Chemical composition

The type of sacrificial alloy is specified in the Job Specification enclosed with the invitation to tender. The sacrificial alloys that shall be used are as follows:

3.1.1 Magnesium alloy

3.1.1.1 Type M1

Mn	Al	Zn	Fe	Cu	Si	Pb	Ni	Others
0.25 min	5-7	2-4	0.005 max	0.08 max	0.3 max	0.03 max	0.003 max	0.3 max

3.1.1.2 Type M2

Mn	Al	Zn	Fe	Cu	Si	Pb	Ni	Others
0.5-1.5	0.05 max	0.03 max	0.03 max	0.02 max	0.05 max	0.01 max	0.002 max	--

3.1.2 Zinc alloys

3.1.2.1 Type Z1

Al	Cd	Fe	Cu	Pb	Others
0.1-0.5	0.025-0.07	0.005 max	0.005 max	0.006 max	0.10 max

3.1.2.2 Type Z2

Al	Cd	Fe	Cu	Pb	Others
0.005 max	0.003 max	0.0014 max	--	--	--

3.1.3 Indium-activated aluminium alloys

Zn	In	Fe	Si	Cu	Others
2.5-6	0.015- 0.030	0.09 max	0.10 max	0.005 max	0.10 max

Any other type of alloy shall be subject to a concession request by the SUPPLIER to the OWNER for approval.

The compositions given in these appendices are only limit ranges. The SUPPLIER shall give a precise indication of the nominal composition of its alloy. The SUPPLIER shall endeavour to guarantee the narrowest possible range, to ensure maximum uniformity of the chemical composition of the anode batch. The SUPPLIER shall also indicate the specific gravity of the alloy, which is used to calculate the anode mass required to determine the submerged weight of the pipelines and the weight of the structures.

3.2 Electrochemical properties

The tender shall indicate the electrochemical properties of the proposed sacrificial alloy (open circuit potential, closed circuit potential, practical mass consumption) in conditions as close as

possible to those of the electrolyte in which the anodes are to operate (specified in the Job Specification). For use in sea water, these properties shall be measured in operating and temperature conditions similar to those of the site, either in natural sea-water or, failing this, artificial sea-water according to [ASTM Standard D 1141](#), with pH adjusted to 8.2 ± 0.1 . The electrolyte shall be continuously replenished.

4. Core quality requirements

The steels used to manufacture anode cores or support fittings on the frame (gusset plates, reinforcing plates or collars) shall be of weldable quality ($C \leq 0.23\%$; $CE \leq 0.40\%$).

All welding operations shall be performed by qualified welders in accordance with a previously qualified welding procedure, submitted to the OWNER for approval.

The procedure shall specify:

- Preparation of joints
- Welding of joints
- Quality of welds and inspections.

A surface treatment ensuring good bonding of the sacrificial alloy to the core shall be applied by the SUPPLIER in accordance with the following rules:

- Sandblasting or grit blasting to Sa 2.5 according to [ISO Standard 8501-1](#). This surface preparation is sufficient if the surface quality is kept in good condition until casting
- For aluminium and magnesium anodes, aluminium spraying may be required if the surface condition obtained by sandblasting is not guaranteed
- For zinc anodes, this operation may be replaced by hot dip galvanising after degreasing and acid pickling.

Any other surface preparation shall be subject to the prior written approval of the OWNER.

5. Massive anodes for fixed or floating structures and containers

5.1 Shape and dimensions

These are indicated in the Job Specification or, failing this, shall be proposed by the SUPPLIER in the tender.

In all cases, the SUPPLIER'S tender shall give the exact values of the net weight, gross weight (including the core and attachment supports) and the dimensions of the anode. The SUPPLIER shall supply a detailed drawing.

Unless otherwise stated in the Job Specification, the tolerances on weight and dimensions shall be as follows:

- Individual anodes of each type shall have a weight within $\pm 3\%$ of the nominal weight for anodes above 50 kg of weight. For anodes weighing less than 50 kg the tolerance shall be $\pm 5\%$.
- The total weight of the delivery should not be more than 2% above the nominal contract weight. No negative tolerance is permitted on the total order.
- The anode mean length shall be $\pm 3\%$ of the nominal length or ± 25 cm whichever is the smaller.

- The anode mean width shall be $\pm 5\%$ of nominal mean width
- The anode mean depth shall be $\pm 5\%$ of nominal mean depth
- The diameter of cylindrical anodes shall be $\pm 5\%$ of nominal diameter.

5.2 Slender anodes with stand-off supports

For slender anodes with stand-off supports, the core shall be cylindrical (tube or round) to avoid gas retention when casting.

The core dimensions shall be proportional to the mass of the sacrificial alloy and to the shaking conditions of the future environment. Unless otherwise specified in the Job Specification, the choices available for these dimensions under normal operating conditions are indicated below.

Diameter of cylindrical cores			
Net mass M of anode (kg)	Inside containers	Structures in the Gulf of Guinea, Mediterranean Sea and Adriatic Sea	Structures in the North Sea
$M < 50$	round $\frac{1}{2}$ "	round $\frac{3}{4}$ "	round $\frac{3}{4}$ "
$50 \leq M < 75$	round $\frac{3}{4}$ "	round $\frac{3}{4}$ "	tube 2" sch 80
$75 \leq M < 150$	round $\frac{3}{4}$ "	tube 2" sch 80	tube 2½" sch 80
$150 \leq M < 200$	tube 2" sch 80	tube 2½" sch 80	tube 3" sch 80
$200 \leq M < 350$	tube 2" sch 80	tube 3" sch 80	tube 4" sch 80
$350 \leq M$	tube 2" sch 80	tube 4" sch 80	tube 4" sch 80

Unless covered by a concession arrangement, the core of slender anodes for offshore structures (especially jackets) shall terminate at the ends of the anodes and not at a side. Stand-off supports shall be made either by core bending to ensure that the sacrificial metal is not loaded during the operation or by welding a cylindrical lug with an elbow added as shown in the drawing in Appendix 1.

The distance "l" between each end of the anode and the axis of the next support lug shall be as short as possible, and shall not exceed the figures below, according to the core diameter.

Maximum anode/support distance "l"				
Core diameter	2"	2" and 2½"	3"	4"
l (mm) maximum	200	300	350	400

The distance "h" between the anode and the leg on which the anode is located, is usually 500 mm, unless otherwise indicated in the Job Specification.

When required for mechanical holding, especially for offshore structures with wall thickness less than $\frac{3}{4}$ ", reinforcement plates shall first be welded to the structure before welding the anode support. This system may be supplemented with a gusset plate reinforcement before welding the anode support. The reinforcement shall be installed as shown in the drawing in Appendix 1 (section 2-2) herein, and the mechanical strength calculation enables the characteristics of the reinforcement plate (length L', thickness) and of the gusset plate (length l', height h', thickness) to be defined.

5.3 Flat or plated anodes

For flat anodes, cores are flat irons of which the number and dimensions (thickness, width) are adapted to the net mass of the sacrificial alloy. Such cores shall terminate laterally to ensure mechanical fixing and electrical contact by welding.

None of the anode surfaces shall be painted, with the exception of plated anodes: their side in contact with the structure shall be given one coat of modified epoxy paint.

6. Bracelet anodes for sea lines

6.1 Shape and dimensions

The shape, approximate dimensions and net mass of the anodes are indicated in the Job Specification. In the tender, in addition to the information requested in Section 3, the SUPPLIER shall specify these dimensions and also indicate the gross mass of the anode.

Unless otherwise stated in the Job Specification, the tolerances on weight and dimensions shall be as follows:

- Individual anodes of each type shall have a weight within $\pm 3\%$ of the nominal weight for anodes above 50 kg of weight. For anodes weighing less than 50 kg the tolerance shall be $\pm 5\%$.
- The total weight of the delivery should not be more than 2% above the nominal contract weight. No negative tolerance is permitted on the total order.
- The length of the anode casting shall be $\pm 3\%$ of nominal length or ± 25 mm, whichever is smaller.
- Anode internal diameter shall conform to the following dimensional tolerances:
 - $-0 + 4$ mm for pipeline diameters less or equal to 300 mm
 - $-0 + 6$ mm for pipeline diameters from 300 to 600 mm
 - $-0 + 1\%$ for pipeline diameters greater than or equal to 600 mm.
- The dimensional tolerances on the anode thickness shall be ± 3 mm.
- The tolerance on the position of the cores with respect to the position on the drawing approved by the OWNER shall be ± 3 mm.

Bevel: For anodes to be installed on a non-concrete pipe, the tips of the half-anodes shall be bevelled to prevent jerks in the passage of tubes in the tensioner and over the "stinger" rollers. In accordance with Appendix 2 the bevel slope shall be such that $65^\circ < \alpha < 75^\circ$.

Coating: None of the anodes surface shall be painted with the exception of the internal surface of anode bracelets, which shall be given one coat of modified epoxy paint.

6.2 Core geometry and fixings

6.2.1 Half-shell anodes

In accordance with Appendix 2, each half-bracelet shall be crossed by two steel cores at least 6 mm thick (usually flat, 30 x 6 mm) drilled with at least three holes to ensure good attachment of the sacrificial alloy. They shall be connected to each other by two half-rings of the same cross-section. At least one of the cores of each half-bracelet shall project outwards to make electrical contact. If required by the mass of the anode, flat or round irons should be added in

the lengthwise direction of the anode. Similarly, the dimensions of the half-rings should be increased. The half-bracelets shall be assembled with two clamping plates made of 30 x 6 mm flat irons to be welded to the non-coated parts of cores in the casting slots.

6.2.2 Segmented anodes

Each half-ring supporting the anodes shall be at least 6 mm thick. The brackets for assembling the half-bracelets shall not project beyond the coated and concrete pipe. The outside of the anodes shall be rounded to a diameter equivalent to the outside diameter of the coated and concrete pipe.

6.2.3 Electrical contact

The lugs serving for electrical contact shall be positioned and shaped to achieve good contact with the pipe from which the coating has been stripped locally.

6.2.3.1 Welding of anode pads

Welding of anode pads is the preferred method for establishing electrical contact between the sacrificial anode and the sea line.

6.2.3.2 Electrical connection through cables

In some cases defined in [GS COR 410](#), electrical connection between anode pads and pipe through cables can be accepted by the OWNER.

7. Physical quality

7.1 Sacrificial alloy/core interface

The sacrificial alloy shall exhibit good adhesion to the core to avoid any mechanical disbonding and ensure excellent electrical contact.

No cavities longer than 10 mm shall appear at this level, and for any divided section, the sum of the lengths of the cavities shall not exceed 5% of the length of the alloy/core interface examined.

7.2 Cracks

The presence of cracks must be minimised. There must be no cracks that could entail a loss of metal. The tolerances are following ones:

Anode type	Position	Maximum number	Maximum width	Length
Slender anodes	Only transverse	≤ 2	≤ 1 mm	≤ 100 mm
Zinc bracelet anodes		≤ 1	≤ 0.5 mm	≤ 50 mm
Al bracelet anodes		≤ 2	≤ 1 mm	≤ 100 mm

The depth of the crack shall not exceed 10% of the sacrificial alloy thickness.

7.3 Surface defects

The surface of the anode shall be free of slag. Each anode shall be cast in one step, i.e. it shall be free of intermediate solidification.

There must be no projecting metal potentially dangerous to users.

Cast shrinkage cavities should be avoided whenever possible, especially on the main surfaces. They may be tolerated up to a depth of 7 mm. There must be no more than two cast shrinkage cavities per anode.

Tapering adjacent to the core termination may be tolerated up to a maximum of 10% of the thickness or equivalent diameter of the anode, to a maximum of 10 mm.

7.4 Internal defects

- No section of the core shall contain more than 2% of cavities. No cavity shall have an area larger than 1 cm²
- No section of the anode shall contain more than 1% of non-metallic inclusions
- The number and method of selection of anodes to be sectioned during a contract should take account of anode design and number of anodes. One anode per anode type shall be selected at random for sectioning. In case of failure to satisfy the acceptance criteria, a second anode shall be selected at random for sectioning. In case of failure to satisfy the acceptance criteria the whole anode batch shall be rejected
- Typically, anodes shall be sectioned transversely by single cuts at 25%, 33% and 50% of nominal length, or at such other agreed locations for a particular anode design (at insert transverse location)
- The cut faces, when examined visually without magnification, shall not have more than:
 - 1% of the sum of the surface area, nor more than 2% or any one surface as gas holes or porosity
 - 0.5% of the sum of the surface area nor more than 1% of any one surface as non-metallic inclusions
 - 5% of the tubular insert circumference containing voids adjacent to the insert as an average of all sections, the maximum for any one section being 10% of the circumference or a maximum of 25 mm.
- For non tubular cores (e.g., channel or "T" section steel) where prevention of voids may be particularly difficult, the limits shall be specified and agreed upon prior to manufacture.

8. Checks to be performed by the SUPPLIER

The SUPPLIER shall perform the checks specified below and submit the results to the OWNER on acceptance.

Inspection shall be performed by the MANUFACTURER'S Inspection Department in the presence of an Inspector appointed by the COMPANY or Engineer.

Inspection results shall be written up in a report and jointly signed by the MANUFACTURER'S Inspection Department Representative and the Inspector.

Inspection shall consist of:

- Size, weight, insert position and identification mark checks. At least 5% of the anodes from each model series shall be examined
- Examination of the spectro-analysis results and the potential and capacity test results
- Examination of cut surfaces; voids, inclusions, insert adherence and position of insert

- Examination of the steel grade used for the inserts and fasteners
- Examination of anode surface condition after removal from the mould.

8.1 Alloy chemical composition

The composition of each melt of the alloy selected shall be checked systematically by the SUPPLIER, who shall perform at least two analyses on each melt (at the beginning and the end). A single analysis is permitted if the melt does not exceed 1,000 kg for zinc and 500 kg for aluminium and magnesium.

The SUPPLIER shall perform these analyses using a method accurate enough for the results to be expressed to the same number of significant figures as those of the nominal composition of the alloy specified in Chapter 3.1.

8.2 Electrochemical properties

Checks on closed-circuit potential and practical mass consumption shall be performed by the SUPPLIER on samples taken during casting (diameter 30 mm, length 150 mm) or preferably on anodes. The fast test method shall be used, and must be submitted to the OWNER for prior approval. Compliance with the methods prescribed by Det Norske Veritas (RP B 401, section 5.7) or by NACE TM 0190 is recommended.

The results of these tests shall conform with the nominal values specified by the SUPPLIER with the following tolerances:

- ± 25 mV for the closed-circuit potential. In addition; no test values more positive than the potential used in the design calculation shall be accepted
- + 5% for the guaranteed practical mass consumption. In addition, no test values of practical mass consumption higher than what is applied in the design calculation shall be accepted.

The OWNER reserves the right to reject the batch of anodes if the results fail to meet the specifications. The OWNER may also postpone acceptance of batches of anodes for which the results of these electrochemical tests are not submitted at the time of inspection.

Unless otherwise indicated in the Job Specification, the electrochemical property checks shall be performed on the following minimum basis:

- One test for an order concerning a net mass of alloy between 0 and 10 t, two tests for 10 to 20 t, and one additional test for every 20 t
- For melts with a chemical composition very near the limits of the range specified by the stated nominal composition, one or more additional tests may be requested.

9. Acceptance

9.1 SUPPLIER's obligations

For orders of more than 4 t of sacrificial metal cast, the SUPPLIER shall provide the OWNER with representative samples of each melt for check analysis.

For each melt, this represents: two samples 30 mm in diameter and 50 mm long, and two samples 30 mm in diameter and 10 mm thick.

If only two samples are taken, they shall be taken at the beginning and end of casting.

In case of disagreement about the composition of the samples, half of each sample shall be exchanged between the Parties and the samples reanalysed.

If the dispute is still not settled, the samples concerned shall be sent to an outside laboratory by both Parties, under conditions to be determined by mutual agreement.

Every 10 t, the SUPPLIER shall also provide the OWNER with a sample 30 mm in diameter and 150 mm long for checking the electrochemical properties in an outside laboratory.

9.2 Marking of anodes

Each anode shall bear the name of the SUPPLIER and be marked with an identification number corresponding to the melt number and the serial No. in the casting. Marking shall be carried out by cold-stamping on the upper third of one of the support tubes, on one of the lugs of the anode, or on the sacrificial alloy. Marking on the sacrificial alloy is tolerated, but is not the preferred method.

9.3 Factory acceptance of anodes

Inspection of the anodes by the OWNER in the factory shall concern the following aspects in particular:

- Gross weight of the anodes
- Number and dimensions of the anodes
- Position of the insert
- Surface appearance of the anodes, especially concerning the possible presence of cavities between the insert and the alloy or within the alloy, as well as the metallurgical structure.

The OWNER reserves the right to cut up to 1% of the number of anodes produced, with a minimum of one anode: each anode may be cut three times in the crosswise direction and once in the lengthwise direction.

A minimum of 10% of the anodes ordered shall be inspected systematically. If no defect is found, acceptance shall be declared for the entire order. Otherwise, inspection shall continue.

9.4 Documents to be supplied

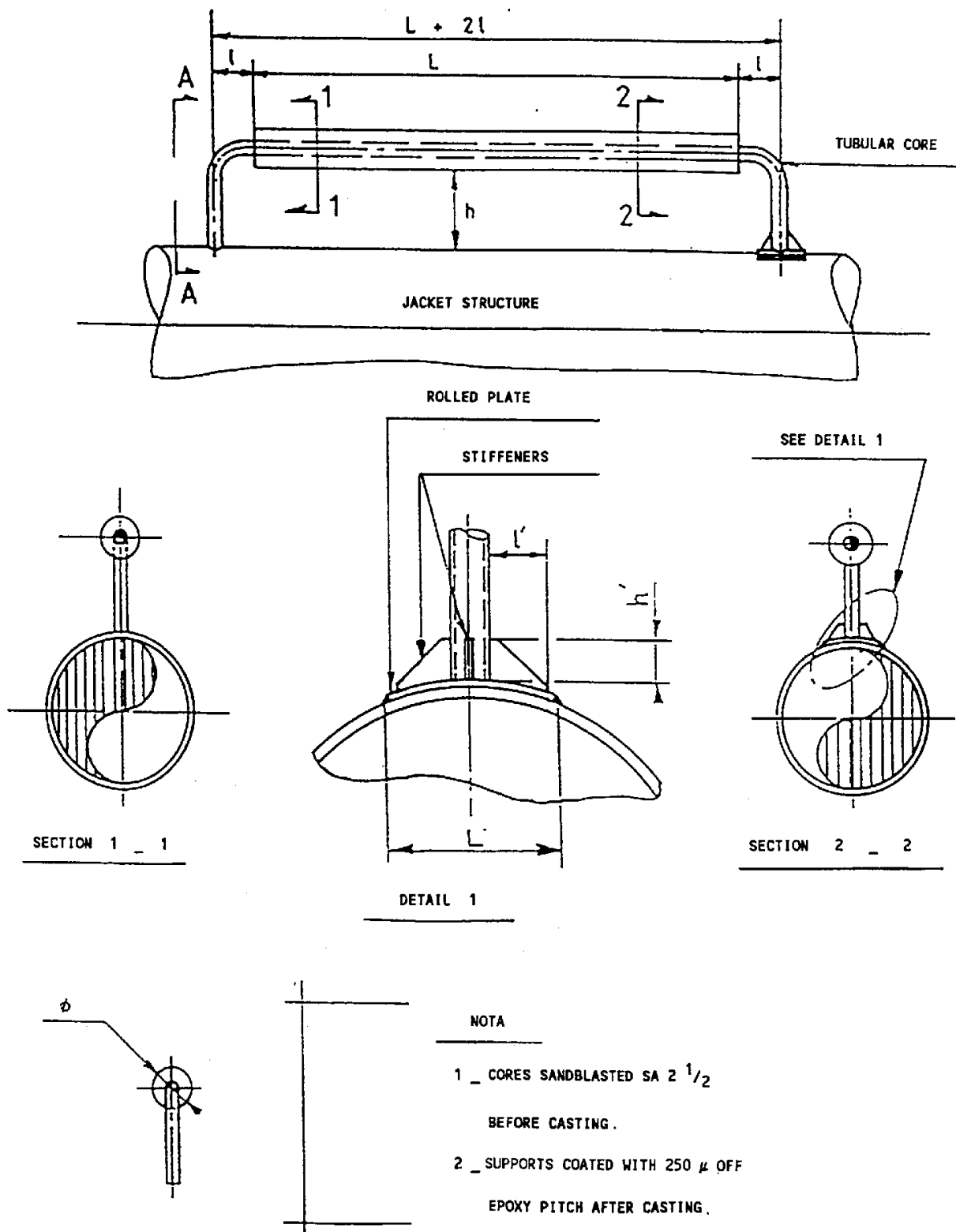
Acceptance of the product shall only be declared on the basis of this inspection and if all the documents to be provided by the SUPPLIER comply with this specification:

- A list of all melts numbered in chronological order and showing each anode with its serial No. and gross weight
- Analysis certificates
- Electrochemical test certificates giving the method, the results and the melt number or the serial No. in the casting operation
- Mill certificates of the steels used.

9.5 On-site acceptance of anodes

Potential and current measurements, supplemented with inspections and photographs, shall be performed by the OWNER during the first year of operation. If it is proved that a certain number of anodes remain blocked and do not function, the warranty clause shall be applied.

Appendix 1 Slender anode with stand-off supports



Appendix 2 Bracelet anode

