Poseidon Pipeline Project - Offshore Section Update

Cathodic Protection Design Report - Offshore

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PROJECT 406010-00159 - CATHODIC PROTECTION DESIGN REPORT - OFFSHORE

REV	DESCRIPTION	ORIG	REVIEW	PM APPROVAL	DATE	CLIENT APPROVAL	DATE
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Appendices

NO TABLE OF CONTENTS ENTRIES FOUND.

1 INTRODUCTION

1.1 Background

The Poseidon Pipeline Project, developed by IGI Poseidon S.A., will be designed for the supply of gas from Turkey and the Eastern Mediterranean region to the European market through the interconnection of the Greek and Italian gas networks.

The Poseidon Pipeline consists of two sections:

- An onshore section, stretching from Kipi (north-east of Greece, next to the Greek Turkish border) to the north western coast of Greece (Thesprotia area);
- An offshore section, from the north-western coast of Greece to Italy (Figure 1-1).

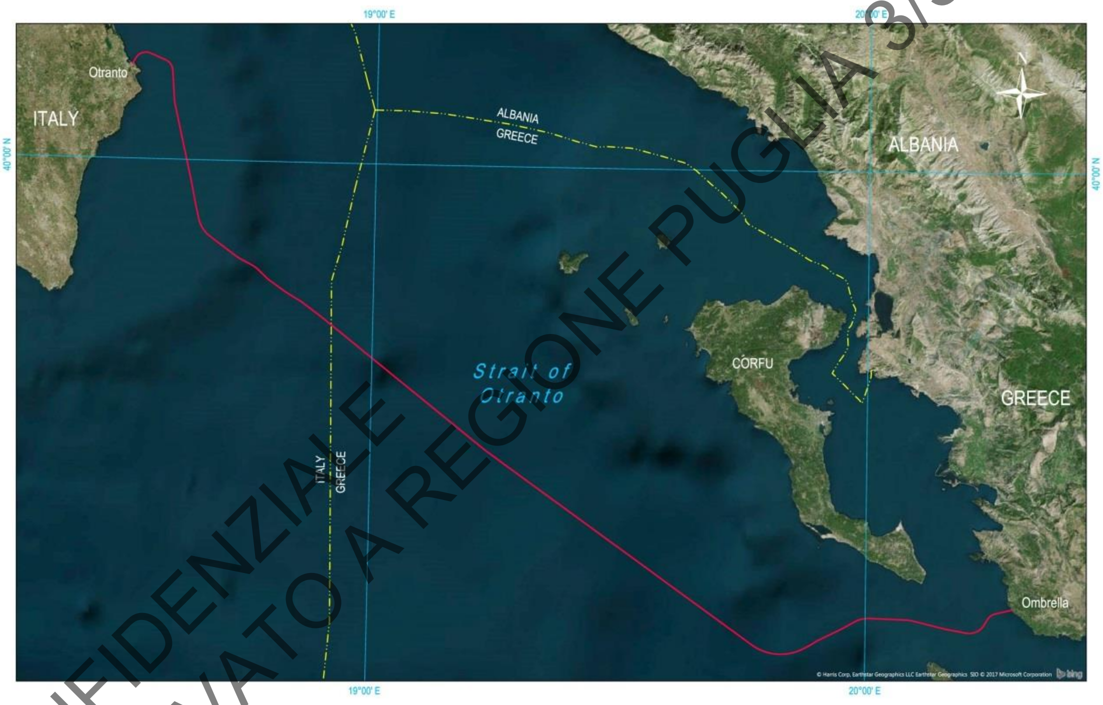

Figure 1-1 Poseidon Pipeline Project – Offshore Section

The offshore section of the Poseidon pipeline comprises:

- A compressor and fiscal metering station next to the Greek landfall (Thesprotia area);
- A deep water offshore pipeline from the Greek landfall to Italy (Otranto, Apulia region). The offshore section (about 200 km, ca. 1,370 m water depth) will cross the Greek shelf, descend the slope into the north Ionian Basin and then ascend the Italian slope, to make landfall east of Otranto;
- A receiving fiscal metering and pressure reduction station in Italy (Otranto, Apulia region);
- Two short buried onshore pipeline sections connecting compressor station in Greece and metering station in Italy to the respective landfalls, including associated scraper launching and receiving facilities.

The FEED phase of the offshore section of the Poseidon Pipeline Project was completed in 2013 and designed for a maximum flow rate of 12 BNCMA of gas (12.66 BSCMA).

ENGINEER's scope of work is named the Poseidon Pipeline Project - Offshore Section Update (the PROJECT). It concerns the Design Update to accommodate a maximum flow rate of 20 BSCMA of gas (which represents a potential development of the gas pipeline, not yet authorized, but evaluated for the maximum design capacity and related technical aspects) for the deep water offshore pipeline from the Greek landfall to Italy (Otranto) and the short onshore buried pipelines connecting compressor station in Greece and fiscal metering and pressure reduction station in Italy to the respective landfalls. Updating of FEED specific aspects for the Greek onshore section, such as the geological, geotechnical, route selection and civil design aspects is not included in the scope.

The document numbers for the FEED Revision have a new CTR number (1000 series).

1.2 Document Scope

This report presents the cathodic protection system (CP) design for the Italian offshore section of the Poseidon pipeline. The design process provides the net anode mass and the number of anodes required to provide cathodic protection to the external steel surface of the pipeline.

2 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Definitions applicable to the Project are provided in Table 2-1.

Table 2-1 Project Definitions

WORK	Scope of Services per CONTRACT for “Poseidon Pipeline Project – Offshore Section Update”
CONTRACT	The CONTRACT between IGI Poseidon and ENGINEER for WORK as detailed in the CONTRACT documents
CLIENT	IGI Poseidon (50% EDISON S.p.A. and 50% DEPA)
INTECSEA	INTECSEA B.V, the engineering company appointed by CLIENT to carry out the WORK
ENGINEER	INTECSEA
Project	The official title of the Project is “Poseidon Pipeline Project – Offshore Section Update”
INTECSEA Project No.	406010-00159

2.2 Abbreviations

Abbreviations applicable to the Project are provided below.

CP	Cathodic Protection
CWC	Concrete Weight Coating
FJC	Field Joint Coating
KP	Kilometre Post
ID	Internal Diameter
PE	Polyethylene
PP	Polypropylene
OD	Outer Diameter
T	Temperature
UC	Unity Check
WT	Wall Thickness

3 DESIGN APPROACH AND CALCULATION METHODOLOGY

3.1 General

The Cathodic Protection design of the offshore pipeline is performed in accordance with recommended practice DNVGL-RP-F103 (Ref. [1]).

The CP design procedure is as follows:

1. Select the anode material and shape,
2. Calculate the combined coating breakdown factors,
3. Calculate the mean and final current demands,
4. Calculate the minimum total net anode mass,
5. Calculate the required minimum total number of anodes, considering the maximum allowable anode spacing.

3.2 Anode Material and Shape

In general, sacrificial anodes for CP in a marine environment are made of a zinc or aluminium alloy. According to industrial standards (Ref. [1] and Ref. [2]), zinc anodes are used for anode surface operating temperatures up to 50°C, whilst aluminium anodes can be used for surface temperatures up to 80°C. Italian local authorities put forward extra requirements when using zinc based anodes.

Based on the above, for the offshore pipeline of the Poseidon Pipeline Project, aluminium anodes have been selected (see Ref. [4]). For proper functioning of the anodes, small amounts of other materials are still required, including a marginal amount of zinc. Hence, it is considered impossible to avoid the presence of any zinc. As per code requirement (Ref. [1]) and the Specification for Anode Fabrication (Ref. [3]), the maximum zinc content is 5.75wt%.

Bracelet anodes are the most commonly used anode shapes for marine pipelines (Ref. [1]). These types of anodes consist of two half-shells which can be clamped directly on the pipeline.

3.3 Combined Coating Breakdown Factors

The mean coating breakdown factors describe the assumed capability of the coating to reduce the current demand for cathodic protection. These factors depend on the pipeline coating type, the presence of concrete weight coating and the system design life. The influence of the pipeline coating type and the presence of concrete weight coating are determined by the factors ”a” and “b” as given in Appendix A of DNVGL-RP-F103 (Ref. [1]): “The constant ‘a’ defines the assumed initial capability of the coating to reduce the current demand for cathodic protection, whilst the constant ‘b’ defines the assumed degradation of this capability over time (“coating breakdown”).”

The mean and final coating breakdown factors are defined as:

$$f_{cm} = a + 0.5 \cdot b \cdot t_f$$
$$f_{cf} = a + b \cdot t_f$$

Where:

a Constant for coating breakdown factor,

b	Constant for coating breakdown factor,
t_f	Design life in years,
f_{cm}	Mean coating breakdown factor,
f_{cf}	Final coating breakdown factor.

The pipeline is protected by anti-corrosion coating and field joint coating at the girth welds. With respect to the field joint coating, a cut-back length of 200 mm is taken into account in the mean and final values of the combined coating breakdown factors as per guidance provided in Ref. [1].

The mean and final combined coating breakdown factors are determined from:

$$f_{cm}' = f_{cm}(linepipe) + 0.033\, f_{cm}(FJC)$$
$$f_{cf}' = f_{cf}(linepipe) + 0.033\, f_{cf}(FJC)$$

Where

f_{cm}'	Combined mean coating breakdown factor
f_{cm} *(linepipe)*	Mean coating breakdown factor of pipeline coating corrosion system
f_{cm} *(FJC)*	Mean coating breakdown factor of field joint coating
f_{cf}'	Combined final coating breakdown factor
f_{cf} *(linepipe)*	Final coating breakdown factor of pipeline coating corrosion system
f_{cf} *(FJC)*	Final coating breakdown factor of field joint coating

3.4 Current Demand

A pipeline can be divided in several sections. The current demand for each section is affected by the surface of the pipeline, the coating breakdown factors and variations in fluid and environmental parameters (e.g. fluid temperature and burial conditions). The effects of the fluid and environmental parameters in the current demand design of a sacrificial anode are given by a recommended design mean current density. The recommended design mean current is selected in accordance with Table 6-2 in Ref. [1].

The mean and final current demands are determined as follows:

$$I_{cm} = A_c \cdot f_{cm} \cdot i_{cm} \cdot k$$
$$I_{cf} = A_c \cdot f_{cf} \cdot i_{cm} \cdot k$$

Where:

I_{cm}	Mean current demand *(A)*,
I_{cf}	Final current demand *(A)*,
A_c	Pipeline surface area *(m²)*,
i_{cm}	Mean current density *(A/m²)*,
k	Design factor as described in Section 4.3.

The pipeline external surface area is defined as:

$$A_c = \pi \cdot OD \cdot L$$

Where:

OD	Pipeline outer diameter *(m)*,
L	Pipeline length *(m)*.

3.5 Minimum Total Net Anode Mass

The minimum total net anode mass is governed by the mean current demand, the design life, the anode utilisation factor and the anode electrochemical capacity.

The anode utilisation factor depends on the shape of the anode. A bracelet anode is designed with an anode utilisation factor of 0.8 (Ref. [2]).

The anode electrochemical capacity depends on variations in fluid and environmental parameters (e.g. fluid temperature and burial condition). The design value of the electrochemical capacity is selected in accordance with Table 6-3 of Ref. [1].

The minimum total net anode mass is calculated from:

$$M = \frac{I_{cm}\ t_f\ 8760}{u\ \varepsilon}$$

Where:

M	Minimum total net anode mass *(kg)*,
u	Anode utilisation factor,
ε	Anode electrochemical capacity *(A·h/kg)*.

3.6 Final Anode Current Output

The final anode current output is directly proportional to the potential difference of the design closed circuit anode potential and the design protective potential, and inversely proportional to the final anode resistance.

Design protective potential (-0.8 V) and closed circuit anode potential values for sediment (-1.00 V) and seawater (-1.05 V) conditions are selected in accordance with Ref. [1].

The final anode current output is defined as:

$$I_{af} = \frac{E_c - E_a}{R_{af}}$$

Where:

I_{af}	Final anode current output *(A)*,
E_a	Design closed circuit anode potential *(V)*,
E_c	Design protective potential *(V)*,
R_{af}	Final anode resistance (Ω).

The final anode resistance of bracelet anodes, which depends on the environmental resistivity and the end of life anode exposed surface area, is defined as follows in Ref. [1]:

$$R_{af} = 0.315\ \frac{\rho}{\sqrt{A_{ea}}}$$

Where:

ρ Environmental resistivity *(Ω·m)*,

A_{ea} The end of life anode surface area *(m²)*.

For seawater resistivity, typical values are provided in Figure A.1 of Ref. [2] for various salinity levels and temperatures. According to the Design Basis Memorandum (Ref. [4]), the seawater resistivity in the Project area varies between 0.15 to 0.20 Ωm.. During the DMS campaign (offshore hydrographic and geophysical survey), seawater resistivity values up to 0.22 Ωm have been reported.

For buried pipeline sections, an actually measured soil resistivity should be applied, corrected for any annual temperature variations. As an alternative, a default value of 1.5 Ωm may be used. Lab testing results performed as part of the Detailed Marine Survey (DMS) shows the following soil resistivity value in the nearshore area (Ref. [5]):

- 0.64 Ωm at 20°C at approximately KP 204.0 (Italian nearshore area)

For CP design of the buried pipeline sections in the nearshore area, a conservative soil resistivity value of 1.5 Ωm is adopted. This is justified by the fact that in case of using engineered backfill, which consists of sandy material, a value of 1.5 Ωm is an appropriate value.

The end of life anode surface area is defined as:

$$A_{ea} = \left(\pi\left(D + 2t_c + 2(1-u)t_a\right) - 2x\right)L_a$$

Where:

t_c External coating thickness *(m)*,

t_a Initial anode thickness *(m)*,

x Anode gap *(m)*,

u Anode utilization factor, see Table 4-5,

L_a Anode length *(m)*.

3.7 Minimum Required Number of Anodes

The minimum required number of anodes is calculated by dividing the final current demand by the final current output.

$$N = \frac{I_{cf}}{I_{af}}$$

Where:

N number of anodes.

3.8 Total Net Anode Mass & Required Number of Anodes

The total net anode mass and required number of anodes is selected based on the following criteria:

- The spacing between the anodes shall be less than 300m as per Ref. [1].

  This requirement results in an anode spacing of 292.8m; this spacing corresponds to the largest number (24) of joints (average pipe length of 12.2m) allowed by Ref. [1].

- The anode lengths shall be selected between 0.5m and 1.0m (practical / handling limitations)

A rule of thumb for the anode length is that the length should be between 0.5 and 1 times the OD of the pipe. For small diameter pipelines, an anode length of approximately one pipe outside diameter is a good starting point to determine the preferred combination of anode dimensions and spacing. For larger pipelines, such as 32-inch, a shorter anode length is feasible.

- In case of non-concrete weight coated pipe sections, a tapered edge shall be applied to prevent anode or equipment damage, by hooking to e.g. the stinger or rollers. A taper angle of 45° is chosen in this CP design. For these sections, a minimum anode thickness of 40mm shall be adopted.
- In case of concrete weight coated pipe sections, the anode thickness is chosen as 5mm less than the CWC thickness and do not have to be tapered allowing for flush installation of the anodes.

For practical, structural and handling reasons, it is advised to restrict the anode dimensions to the extent possible.

4 DESIGN DATA

This section presents the design data used in the CP design. The design data are taken from the Design Basis Memorandum (Ref. [4]) and DNVGL-RP-F103 (Ref. [1]), unless otherwise stated.

4.1 Design Life

The pipeline design life is 30 years, with a possible extension to 50 years. The calculations performed are for a design life of 50 years.

4.2 Pipeline Data

The pipeline data for CP design are presented in Table 4-1.

Table 4-1: Pipeline Data

Description	Unit	Value
Pipeline steel grade	-	DNV SAWL 485
Pipe joint length	m	11.7 to 12.5 (12.2 average)
Design protective potential	V	- 0.80
Corrosion coating type	-	3LPP
Corrosion coating thickness	mm	3.0
Field Joint Coating (type 2B in Ref. [1])	-	Heat shrink sleeve PP
Coating breakdown factor constant “a” for 3LPP	%	0.1 1)
Coating breakdown factor constant “b” for 3LPP	%	0.003 1)
Coating breakdown factor constant “a” for FJC	%	3.0 2)
Coating breakdown factor constant “b” for FJC	%	0.3 2)

Note 1: Table A-1 in Ref. [1]
Note 2: Table A-2 in Ref. [1]

The minimum anode requirement is a function of the condition of the pipeline: if it is buried, how warm it will become, whether there is a concrete weight coating present etc.

For calculation of the CP system, the Poseidon offshore pipeline is divided in multiple segments as shown in Table 4-2.

Table 4-2: Italian Pipeline Properties per Segment

Section	KP (km)	CWC (mm)	OD pipe (mm)	WT pipe (mm)	Max T_{pipe} (°C)	Buried
1	140.0 – 160.2	0	812.8	30.7	<25°C	No
2	160.2 – 162.8	50	812.8	20.0	<25°C	No
3	162.8 – 185.2	70	812.8	20.0	<25°C	No
4	185.2 – 203.3	90	812.8	20.0	<25°C	No
5	203.3 – 203.7	110	812.8	20.0	<25°C	No
6	203.7 – 204.34	120	812.8	30.7	<25°C	No
7	204.34 – 204.8	0	812.8	30.7	<25°C	HDD

The internal operating fluid temperatures shown are summer temperatures (conservative), and are obtained from Ref. [12].

The maximum system operating temperature of the Poseidon pipeline is 60°C, whereas the maximum design temperature is equal to 70°C (Ref. [4]). The design temperature can only be reached in the event of an upset condition, i.e. failure of coolers at the compressor station. Therefore, this temperature is not used for CP design.

For details on the wall thickness and concrete weight coating requirements, reference is made to the Pipeline Mechanical Design Report (Ref. [13]) and On-Bottom Stability Design Report (Ref. [14]).

4.3 Environmental Data

The environmental data for the CP design are presented in Table 4-3.

Table 4-3: Environmental Data

Description	Unit	Value	Reference
Minimum seawater temperature at seabed	°C	12.4	Ref. [4]
Sediments resistivity (nearshore)	Ωm	1.50	Section 3.6
Seawater resistivity	Ωm	0.22	Section 3.6

The recommended design mean current density according to Ref. [1] is dependent on temperature, and is shown in Table 4-4.

Table 4-4: Recommended Design Mean Current Density (A/m2)

Exposure condition	Internal fluid temperature (°C)		
	<25	> 25 – 50	> 50 – 80
Non-buried	0.050	0.060	0.075
Buried	0.020	0.030	0.040

In calculation of the current demand, a design factor *k* of 2 is applied in line with DNV Section 6.1.5 (Ref. [1]). This design factor accounts for uncertainties in the various design parameters.

4.4 Anode Data

The anode data for the CP design are presented in Table 4-5. The anode surface design temperature is assumed to be equal to the internal operating fluid temperature (conservative).

Table 4-5: Anode Data

Description	Unit	Value
Type	-	Half Shell Bracelet
Anode composition	-	Aluminium based alloy
Anode material density	kg/m^3	2,750
Close circuit anode potential in sediment	V	-1.00
Close circuit anode potential in seawater	V	-1.05
Utilization factor	-	0.8
Anode gap between bracelets (assumed value)	mm	100

The electrochemical capacity of the anode is a function of temperature (Ref. [1]), and is shown in Table 4-6. For temperature values in between the mentioned values, the design mean current density should be interpolated.

Table 4-6: Electrochemical Capacity of Anode [Ah/kg]

Anode surface temperature	Case	
	Non-buried	Buried
≤30 °C	2000	1500
60 °C	1500	680
80 °C	720	320

4.5 Alternative Design Case – Self Burial

As indicated in the Sediment Transport Study Report (Ref. [10]), seabed mobility could cause the pipeline to become (partly) buried at the end of life.

As such, an alternative case has been investigated in which the pipeline is assumed to be completely buried. Compared to the base case, this scenario accounts for:

- An increased environmental resistivity value, see below,
- A decreased design mean current density, as shown in Table 4-4,
- An increased close circuit anode potential, as shown in Table 4-5,

- A decreased electrochemical capacity of the anode, as shown in Table 4-6,

For the environmental resistivity value in case of a fully buried pipeline, the electrical resistivity test results of the geotechnical samples along the pipeline route are used (Ref. [5]). The test results show that in the top soils layer (up to 0.5m below seabed), the electrical resistivity varies between 0.39 Ωm and 0.78 Ωm.

Due to large variability between the reported electrical resistivity values and the guidance in Ref. [1], a conservative soil resistivity value of 1.5 Ωm is adopted.

5 RESULTS AND DISCUSSION

Table 5-1 presents the selected anode dimensions and anode mass for each pipe segment as defined in Table 4-2. The anode dimensions are mainly governed by the following requirements:

- Total net anode mass shall meet the mean current demand as defined in Section 6.4 of Ref. [1];
- The minimum mass per anode should provide sufficient final current density, as described in Section 6.3.1 and 6.5.1 of Ref. [1];
- Selected anode dimensions fulfils the criteria as stipulated in Section 3.8 of this document

The number of anodes presented in Table 5-1 is based on an anode spacing of 292.8m as described in Section 3.8.

The taper lengths of both anode T-1 and anode T-2 are 40mm, as based on the 45deg taper angle as described in Section 3.8.

In Table 5-2 Unity checks (UC) are presented for the required anode mass and current demand, which are calculated as follows respectively.

$$UC_{mass} = \frac{M}{M_{actual} \cdot N}$$

$$UC_{CD} = \frac{I_{cf}}{I_{af} \cdot N}$$

Where:

M	Minimum total net anode mass *(kg)*,
M_{actual}	Actual anode mass obtained from geometry and density *(kg)*,
N	Number of anodes,
I_{af}	Final anode current output per anode *(A)*,
I_{cf}	Final current demand *(A)*.

The UC values should be equal or below 1.00 to satisfy the requirements posed in Ref. [1].

The average and final current demand and final current output per section are shown in Table 5-3.

Table 5-1: Selected Anode Configuration

Section	KP (km)	Anode type (Ref. [8])	Number of anodes	Anode Length (mm)	Anode Thickness (mm)	Net Anode Mass (kg) 1)	Anode inner diameter (mm) 4)
1	140.0 – 160.2	T-3-32	69	500	40	130	818.8
2	160.2 – 162.8	S-6-32	9	500	45	136	818.8
3	162.8 – 185.2	S-7-32	77	500	65	207	818.8
4	185.2 – 203.3	S-8-32	62	500	85	270	818.8
5	203.3 – 203.7	S-9-32	2	500	105	351	818.8
6	203.7 – 204.34	S-10-32	3 + 3 2)	600	115	466	818.8
7	204.34 – 204.8	Note 3					

Note 1: On the basis of two half shells; net anode mass assumes that 90% of anode volume comprises anode material (Al-alloy)

Note 2: Within the nearshore pipeline section, it is recommended that the minimum anode spacing be reduced to 150 meters or less, in order to safeguard against any potential onshore current drains that could result in the early depletion of the offshore anodes. Therefore, extra amount of anodes will be installed just before the shore crossing.

Note 3: The last 570 meter of pipeline on the Italian side will be installed by means of a HDD section. Cathodic protection requirements of this section are separately assessed in Subsection 5.1.

Note 4: The anode inner diameter is the pipe outside diameter plus two times the coating thickness. In the detailed design the inner diameter shall be verified to ensure a good fit, also accounting for tolerances.

Table 5-2: CP Design Unity Checks

Section	KP (km)	Base Case			Self-Burial Case		
		Buried	UC_{mass}	UC_{cd}	Buried	UC_{mass}	UC_{cd}
1	140.0 – 160.2	N	0.83	0.16	Y	0.44	0.54
2	160.2 – 162.8	N	0.75	0.16	Y	0.40	0.53
3	162.8 – 185.2	N	0.51	0.16	Y	0.27	0.54
4	185.2 – 203.3	N	0.38	0.16	Y	0.20	0.53
5	203.3 – 203.7	N	0.21	0.11	Y	0.11	0.36
6	203.7 – 204.34	N	0.17	0.10	Y	0.09	0.35

Table 5-3: CP Design, Current Demand and Output (per Section)

Section	KP (km)	Base Case			Self-Burial Case		
		Average Current Demand (A)	Final Current Demand (A)	Final Current Output (A)	Average Current Demand (A)	Final Current Demand (A)	Final Current Output (A)
1	140.0 – 160.2	26.9	43.5	274.0	10.8	17.4	32.1
2	160.2 – 162.8	3.4	5.5	35.3	1.3	2.2	4.1
3	162.8 – 185.2	29.8	48.3	307.7	11.9	19.3	36.1
4	185.2 – 203.3	23.5	38	245.6	9.4	15.2	28.8
5	203.3 – 203.7	0.5	0.9	8.1	0.2	0.3	0.9
6	203.7 – 204.34	0.9	1.4	13.3	0.3	0.6	1.6

As described in this document, the minimum anode dimensions are governed by practical, structural and handling limitations, over-dimensioning of the anodes is unavoidable for some offshore pipeline sections; in particular for the concrete weight coated sections requiring flush installation of the anodes.

Total type of anodes is driven by the number of selected concrete weight coating thicknesses:

- 1-off anode type per concrete weight coating thickness for concrete weight coated pipeline sections
- 1-off anode type for non-concrete weight coated pipeline sections (tapered ends)

The types of anodes are shown in the Anode General Arrangement Drawing (Ref. [6]).

The selected anode dimensions and positions will be reflected in the Alignment Sheets (Ref. [7]) and included in the Pipeline Component Material Take-Off (Ref. [8]).

5.1 Italian Shore Crossing

The last 570 meter of pipeline on the Italian side will be installed by means of a HDD section as per Shore Crossing Design Report – Italy (Ref. [9]). To minimise the risk of coating damage, it is recommended to use a thicker anti-corrosion coating layer (6mm instead of 3mm) with an abrasive resistant outer layer to prevent damage during pipeline installation in the HDD section

The anode(s) shall be placed directly upstream of the HDD section. This way the functionality of the anode (in seawater) is guaranteed. The conductivity of surrounding soil is assumed equal to a buried pipeline. With these parameters the attenuation length (i.e. the protective length one anode can cover) is sufficient to protect the pipeline in the HDD section

The attenuation length is calculated with the equation shown below (Ref. [1]).

$$L = \frac{d \cdot (D-d)}{\rho_{Me} \cdot D \cdot f'_{cf} \cdot i_{cm}} \left[\frac{-R_{af} \cdot I_{cf(tot)}}{L_{tot}} + \sqrt{\left(\frac{R_{af} \cdot I_{cf(tot)}}{L_{tot}}\right)^2 + \frac{\rho_{Me} \cdot i_{cm} \cdot k \cdot f'_{cf} \cdot D}{d \cdot (D-d)} \left(E_p - E_a^0\right)} \right]$$

Where:

D outer diameter of the pipeline steel;

d wall thickness;

ρ_{Me} electric resistivity of the line pipe;

f'_{cf} final coating breakdown factor;

i_{cm} design mean current density;

k design factor;

R_{af} anode resistivity;

$I_{cf(tot)}$ final current demand, including design factor (k);

L_{tot} pipeline section length;

E_p design protective potential;

E_a^0 selected design closed circuit anode potential.

Substituting the variables results in an attenuation length of 603m, which is sufficient to cover the 570m pipe in the HDD section

6 CONCLUSION

The cathodic protection system for the Italian section of the Poseidon Pipeline system consists of 222 aluminium based full shell bracelet anodes, with a minimum total weight of approximately 46,500 kg.

To meet the pipeline properties (pipe outside diameter, concrete weight coating thickness) and the minimum anode mass requirement, various types of anodes are foreseen, varying in length and in thickness. The thickness range depends on the selected concrete weight coating thickness along the pipeline route.

The selected anode dimensions are shown on the Alignment Sheets (Ref. [7]) and included in the Pipeline Component Material Take-Off (Ref. [8]).

It has to be kept in mind that the final anode design to be performed during detailed design is driven by the selected anode manufacturer and the availability of anode moulds. Furthermore, the final dimensions of the anode internal diameters should be sized to ensure a good fit to the various pipeline outside diameter values (including pipeline OD tolerances) to minimise the risk of damage to anodes from tensioner loads during installation.

The fabrication specification and installation specification are to be found in reference documents Ref. [3] and Ref. [15], respectively.

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7 REFERENCES

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Ref. [7] INTECSEA, Poseidon Pipeline Project – Offshore Section Update, Offshore Pipeline Alignment Sheets, IGI-1316-30-PL-DWG-001.

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