MATERIAL SELECTION REPORT

OSC-30-H004-Z-RA-00004

1107304 OCEAN SPACE CENTRE

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PROJECT OCEAN SPACE CENTRE

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1 Table of Content

1 Introduction

1.1 Objectives

The purpose of this document is to serve as a guide for selection and corrosion protection of metallic, polymeric and ceramic materials for the Ocean Space Center.

1.2 Definitions and abbreviations

Definitions:

Company:	Statsbygg, which is the Norwegian government's key advisor in construction and property affairs, building commissioner, property manager and property developer.
Contractor:	Means the party named as such in the Form of Agreement
Subcontractor:	Means a Third Party who has entered into an agreement with the Contractor for the supply of goods or services in connection with the Work.
End-user:	SINTEF Ocean and NTNU
Work:	Means all work which Contractor shall perform or cause to be performed in accordance with the Contract
Company Materials:	Means equipment, systems, and/or materials supplied by Company, and which are to be incorporated in the Contract Object.

Abbreviations:

ISO	-	International Organization for Standardisation
QC	-	Quality Control
RH	-	Relative Humidity

1.3 Standards and Regulations

The following standards/requirements and norms applies for the Work:

DNV-OS-C501	Composite Components
EN 1090-3	Utførelse av stålkonstruksjoner og aluminiumkonstruksjoner - Del 3: Tekniske krav til aluminiumkonstruksjoner
EN 14399-1	Høyfaste skrueforbindelser for forspenning til konstruksjonsformål - Del 1: Generelle krav
EN 15048-1	Sammensetning av ikke-forspente konstruksjonsbolter - Del 1: Generelle krav
EN ISO 10683	Festeelementer - Ikke-elektrolytisk påførte sinkflakbelegg
EN ISO 10684	Festelementer - Varmforsinkede belegg
EN ISO 4042	Festeelementer - Elektrolytiske beleggsystemer
ISO 9588	Metallic and other inorganic coatings — Post-coating treatments of iron or steel to reduce the risk of hydrogen embrittlement
NORSOK M-102	Structural aluminium fabrication
NORSOK M-120	Material data sheets for structural steel
NORSOK M-121	Aluminium structural material
NORSOK M-601	Welding and inspection of piping
NE-EN 898	Mechanical properties of fasteners made of carbon steel and alloy steel
NS-EN 1090-1	Utførelse av stålkonstruksjoner og aluminiumkonstruksjoner - Del 1: Krav til samsvarsvurdering av lastbærende komponenter
NS-EN 1090-2	Utførelse av stålkonstruksjoner og aluminiumkonstruksjoner - Del 2: Tekniske krav til stålkonstruksjoner
NS-EN 1090-3	Utførelse av stålkonstruksjoner og aluminiumkonstruksjoner - Del 3: Tekniske krav til aluminiumkonstruksjoner
NS-EN 1999	Eurokode 9: Prosjektering av aluminiumskonstruksjoner
NS-EN 13480	Metalliske industrielle rørsystemer
NS-EN ISO 17635	Ikke-destruktiv prøving av sveiser - Generelle regler for metalliske materiale
NS-EN ISO 9712	Ikke-destruktiv prøving — Kvalifisering og sertifisering av NDT-personel
NS-EN 10025	Hot rolled products of structural steels
OSC-30-H004-Z-RA-00002	Requirements for corrosion protective coatings

2 Scope of work

This document applies as a guideline for material selection and corrosion protection for the Ocean Space Center. Original equipment manufacturer, or systems that are delivered as a total delivery, that can document the products lifetime in the relevant corrosion class, either by testing or field service, is not regarded as part of scope for this specification.

3 General requirements

Material selection shall be optimised and provide acceptable safety and reliability. As a minimum, the following shall be considered:

- corrosivity
- design life
- failure probabilities, failure modes and failure consequences for human health, safety and material assets;
- inspection and corrosion monitoring;
- access and philosophy for maintenance and repair;
- minimum and maximum design temperature;
- weldability

For the final material selection, the following additional factors shall be included in the evaluation:

- Priority shall be given to materials with good market availability and documented fabrication and service performance.
- Number of different materials shall be minimised considering stock, costs, interchangeability and availability of relevant spare parts.

3.1 Environmental conditions

Room temperature	20°C
Water temperature	15-20°C
Water chemistry	1 ppm Cl^-
pH	6.8-8.0

The environmental conditions should be considered according to table 1 and 2 in ISO 12944-2, Figure 1 and Figure 2, and material selection should be based on the relevant category in this report.

Table 1 — Atmospheric-corrosivity categories and examples of typical environments

Corrosivity category	Mass loss per unit surface/thickness loss (after first year of exposure)				Examples of typical environments (informative only)	
	Low-carbon steel		Zinc		Exterior	Interior
	Mass loss g/m²	Thickness loss µm	Mass loss g/m²	Thickness loss µm		
C1 very low	≤ 10	≤ 1,3	≤ 0,7	≤ 0,1	—	Heated buildings with clean atmospheres, e.g. offices, shops, schools, hotels
C2 low	> 10 to 200	> 1,3 to 25	> 0,7 to 5	> 0,1 to 0,7	Atmospheres with low level of pollution: mostly rural areas	Unheated buildings where condensation can occur, e.g. depots, sports halls
C3 medium	> 200 to 400	> 25 to 50	> 5 to 15	> 0,7 to 2,1	Urban and industrial atmospheres, moderate sulfur dioxide pollution; coastal areas with low salinity	Production rooms with high humidity and some air pollution, e.g. food-processing plants, laundries, breweries, dairies
C4 high	> 400 to 650	> 50 to 80	> 15 to 30	> 2,1 to 4,2	Industrial areas and coastal areas with moderate salinity	Chemical plants, swimming pools, coastal ship and boatyards
C5 very high	> 650 to 1 500	> 80 to 200	> 30 to 60	> 4,2 to 8,4	Industrial areas with high humidity and aggressive atmosphere and coastal areas with high salinity	Buildings or areas with almost permanent condensation and with high pollution
CX extreme	> 1 500 to 5 500	> 200 to 700	> 60 to 180	> 8,4 to 25	Offshore areas with high salinity and industrial areas with extreme humidity and aggressive atmosphere and subtropical and tropical atmospheres	Industrial areas with extreme humidity and aggressive atmosphere
NOTE The loss values used for the corrosivity categories are identical to those given in ISO 9223.						

Figure 1: Classification of environment according to ISO 12944-2

Table 2 — Categories for water and soil

Category	Environment	Examples of environments and structures
Im1	Fresh water	River installations, hydro-electric power plants
Im2	Sea or brackish water	Immersed structures without cathodic protection (e.g. harbour areas with structures like sluice gates, locks or jetties)
Im3	Soil	Buried tanks, steel piles, steel pipes
Im4	Sea or brackish water	Immersed structures with cathodic protection (e.g. offshore structures)
NOTE For corrosivity category Im1 and Im3, cathodic protection can be used with a paint system tested accordingly		

Figure 2 Classification of submerged enviroments according to ISO 12944-2

Category	Areas of the building	Risk of corrosion
C1	Heated, ventilated rooms with low humidity. Offices, hallways etc	Very low
C2	Areas where condensation might occur. Lab areas with pool. Limited down to 0.5 meters over the water surface, since the room temperature and ventilation will control the relative humidity of the room, reducing risk of condensation.	Low, however some consideration must be taken.
C3-IM1	Areas with high humidity, risk of direct contact with water and submerged structures. Limited to 0.5 meters over the water surface, due to the low risk of high waves, and the low humidity of the room.	Medium, must be considered when designing.

Figure 3: Classification of the environment for OSC

4 Corrosivity Class C1

4.1 Material selection

In corrosion class C1 environment, corrosion is regarded as very low. Material selection can, hence, be based on other criteria regarded as “fit for function”. Material quality shall be in accordance with requirements in ISO-EN 10025- all parts or equal.

4.2 Welding

Welding of structural steel shall be in accordance with requirements of NS-EN 1090-2.

Welding of piping material shall be in accordance with requirements of EN 13480.

Stainless steel welds shall be visually inspected in accordance acceptance criterias in NORSOK M-601 Annex B.

4.3 NDE

NDE shall be in accordance with NS-EN 1090.

NDE operators shall be qualified in accordance with NS-EN ISO 9712.

4.4 Mechanical fasteners

Mechanical fasteners shall comply with requirements in NS-EN 1090-2/3. The corrosion resistance of the bolting assemblies, other fasteners and sealing washers shall be comparable to that specified for the fastened components.

- Hot dip galvanized coatings of fasteners shall conform to EN ISO 10684.
- Electroplated coatings of fasteners shall conform to EN ISO 4042.
- Non-electrolytically applied zinc flake coatings of fasteners shall conform to EN ISO 10683.

Protective coatings of components for mechanical fasteners shall comply with the requirements of the relevant product standard or, in the absence thereof, with the manufacturer's recommendation.

For bolting assemblies with property class 10.9 or hardness greater than 32 HRC, risk of hydrogen embrittlement during electroplating or hot dip galvanizing of bolting shall be addressed and baking shall be specified. Baking shall be performed in accordance with ISO 9588 to class ER-9.

5 Corrosivity Class C2

Low corrosivity level, low levels of pollution, moderate temperature, for the OSC this will include the laboratory areas and all facilities that are located more than 0.5 meter from the water surface.

5.1 Material selection

Material selection shall be based on assumption that corrosion might occur. Material selection and surface protection shall be such that general corrosion is cost effectively prevented. Carbon steel shall always have external surface protection when exposed to external atmospheric environment in accordance with OSC-30-H004-Z-RA-00002 “Requirements for corrosion protective coatings”. Materials that are regarded as “stainless” is not expected to suffer from corrosion in this environment. However, special attention should be paid to surfaces where condensation might occur. When designing in C2, probability of corrosion should be evaluated.

Materials regarded as corrosion resistant are:

- Aluminium
- Titanium
- Uninsulated stainless steel
- Insulated stainless steel heating/ventilation/air-conditioning ducts
- Chrome/nickel plating
- Copper
- Brass
- Lead
- Plastic or similar

Materials regarded as corrosion resistant will not need to be protected from corrosion by a coating. If the parts are to be coated due to esthetic or functional requirements, the chosen coating systems must be evaluated by the Contractor, in order not to reduce the corrosion resistance by affecting the protective oxide layer of the stainless material.

5.2 Welding

Welding of structural steel shall be in accordance with requirements of ISO 1090.

Welding of piping material shall be in accordance with requirements of NS-EN 13480.

Stainless steel welds shall be visually inspected in accordance requirements in NORSOK M-601 Annex B.

5.3 NDE

NDE shall be in accordance with NS-EN ISO 17635.

NDE operators shall be qualified in accordance with NS-EN ISO 9712.

5.3.1 Dissimilar welding

If stainless steel is connected to carbon steel, the stainless steel part shall be coated to 50 mm beyond the weld zone onto the stainless steel.

Care shall be taken when choosing welding consumables to make sure that the corrosion resistance of the entire weld metal, HAZ and base metal are compatible with the environment.

5.4 Mechanical fasteners

Mechanical fasteners shall comply with requirements of ISO 1090. The corrosion resistance of the bolting assemblies, other fasteners and sealing washers shall be comparable to that specified for the fastened components.

In C2 environment the need for improved atmospheric corrosion resistance material shall be evaluated. Grade 8.8 ISO 898 would be suitable. Their mechanical characteristics, performances and delivery conditions shall conform to the requirements in EN 14399-1 or EN 15048-1 as relevant. The minimum specified strength and/or hardness of the nut shall not be less than for the bolt to avoid thread stripping.

- Hot dip galvanized coatings of fasteners shall conform to EN ISO 10684.
- Electroplated coatings of fasteners shall conform to EN ISO 4042.
- Non-electrolytically applied zinc flake coatings of fasteners shall conform to EN ISO 10683.

Protective coatings of components for mechanical fasteners shall comply with the requirements of the relevant product standard or, in the absence thereof, OSC-30-H004-Z-RA-00002 “Requirements for corrosion protective coatings”.

For bolting assemblies with property class 10.9 or hardness greater than 32 HRC, risk of hydrogen embrittlement during electroplating or hot dip galvanizing of bolting shall be addressed and baking shall be specified. MPa. Baking shall be performed in accordance with ISO 9588 to class ER-9

6 Corrosivity class C3 and IM1

For the OSC the C3 areas are limited to 0,5 meter form the pool surface, hence material selection for C3 and IM1 can be regarded the same. In category C3 and IM1, corrosion must be considered when designing. All materials, that are not regarded as stainless, shall be protected from corrosion in accordance with OSC-30-H004-Z-RA-00002 “Requirements for corrosion protective coatings”.

- Stainless steels such as type 316 SS or lean duplex SS for structural purpose do not require coating.
- Aluminium base alloys shall be selected among those given in NORSOK M-121. Fabrication of aluminium structures shall be according to NORSOK M-102 (under development) and NS-EN 1090-3. All aluminum shall comply with requirements of NS-EN 1999.
- Fibre reinforced plastic Components to be made from FRP/GRP materials shall be designed according to DNV-OS-C501.
- For piping PE should be considered as a cost effective alternative to stainless steels.

Materials regarded as corrosion resistant will not need to be protected from corrosion by a coating. If the parts are to be coated due to esthetic or functional requirements, the chosen coating systems must be evaluated by the Contractor in order not to reduce the corrosion resistance by affecting the protective oxide layer of the stainless material.

6.1 Galvanic corrosion prevention

Wherever dissimilar metals are coupled together, a corrosivity evaluation shall be made. If galvanic corrosion is likely to occur, it can be assumed that the local corrosion rate near the interface is approximately 3 times higher than the average corrosion rate, decreasing exponentially away from the interface. Galvanic corrosion can be mitigated by:

- Apply electrical insulation of dissimilar metals. Possible electrical connection via pipe supports, deck and earthing cables shall be considered.
- Apply a non-conducting coating on the most noble of the dissimilar metals.
- Dissimilar welds between carbon steel and stainless shall be coated to 50 mm beyond the weld zone onto the stainless steel.

Direct contact between aluminium and carbon steel shall be prevented in C3 and IM1 environments. Aluminium and steel (carbon steel and stainless steel) surfaces shall in general be segregated with pads made of non-metallic materials such as rubber. If the aluminum is anodized in accordance with MIL-A-8625, type III, this surface treatment will insulate the part and protect from corrosion.

6.2 Welding

Welding of structural steel shall be in accordance with requirements of ISO 1090.

Welding of piping material shall be in accordance with requirements of NS-EN 13480.

Stainless steel welds shall be visually inspected in accordance requirements in NORSOK M-601 Annex B.

If stainless steel is connected to carbon steel, the stainless steel part shall be coated to 50 mm beyond the weld zone onto the stainless steel.

Care shall be taken when choosing welding consumables to make sure that the corrosion resistance of the entire weld metal, HAZ and base metal are compatible with the environment. In addition, corrosion testing may be necessary to demonstrate adequate corrosion resistance.

6.3 NDE

NDE shall be in accordance with NS-EN ISO 17635.

NDE operators shall be qualified in accordance with NS-EN ISO 9712.

6.4 Mechanical fasteners

Mechanical fasteners shall comply with requirements of ISO 1090. The corrosion resistance of the bolting assemblies, other fasteners and sealing washers shall be comparable to that specified for the fastened components. In C2 environment the need for improved atmospheric corrosion resistance material shall be evaluated. Grade 8.8 according to ISO 898 would be suitable. Their mechanical characteristics, performances and delivery conditions shall conform to the requirements in EN 14399-1 or EN 15048-1 as relevant. The minimum specified strength and/or hardness of the nut shall not be less than for the bolt to avoid thread stripping.

- Hot dip galvanized coatings of fasteners shall conform to EN ISO 10684.
- Non-electrolytically applied zinc flake coatings of fasteners shall conform to EN ISO 10683.

Protective coatings of components for mechanical fasteners shall comply with the requirements of the relevant product standard or, in the absence thereof, OSC-30-H004-Z-RA-00002 “Requirements for corrosion protective coatings”.

For bolting assemblies with property class 10.9 or hardness greater than 32 HRC, risk of hydrogen embrittlement during electroplating or hot dip galvanizing of bolting shall be addressed and baking shall be specified. MPa. Baking shall be performed in accordance with ISO 9588 to class ER-9.

7 Pre Production Meeting (PPM)

Prior to production start, should a PPM be arranged. The agenda for this meeting should be based on a checklist, ensuring that the requirements of NS-EN 1090-2/3/4 section 4 and 5, OSC-30-H004-Z-RA-00002 and this document are meet for the materials selected and that the subcontractor are qualified for the work.