

## Surface preparation and protective coating

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Standards Norway  
Strandveien 18, P.O. Box 242  
N-1326 Lysaker  
NORWAY

Telephone: + 47 67 83 86 00  
Fax: + 47 67 83 86 01  
Email: [petroleum@standard.no](mailto:petroleum@standard.no)  
Website: [www.standard.no/petroleum](http://www.standard.no/petroleum)

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## Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are, as far as possible, intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF), The Federation of Norwegian Industry, Norwegian Ship owners' Association and The Petroleum Safety Authority Norway.

NORSOK standards are administered and published by Standards Norway.

## Introduction

The main changes included in this edition are that

- the content of a paint report and an example of such is included,
- additional requirements for surface protection of valves actuators, gearboxes, pumps and motors are implemented,
- requirements for reinforcement and anchoring of sprayed fire protecting with fibre mesh are given,
- requirements for subsea coatings at higher temperature than 50 °C is given,
- IMO MSC215(82) classification testing has been accepted as an alternative qualification method for ballast water tank coatings (coating system no. 3B),
- more detailed specification of what to include in the coating procedure specification is given,
- a time limit for the validity of the coating procedure test is specified,
- coating system numbering is made more detailed for system no. 6 and system no. 7,
- polyester based powder coating is included as an alternative on top of hot dipped galvanized steel and aluminium based structures,
- coating system for subsea is split into three categories.

## 1 Scope

This NORSOK standard gives the requirements for the selection of coating materials, surface preparation, application procedures and inspection for protective coatings to be applied during the construction and installation of offshore installations and associated facilities.

This NORSOK standard cover paints, metallic coatings and application of spray-on passive fire protective coatings.

The aim of this NORSOK standard is to obtain a coating system, which ensures

- optimal protection of the installation with a minimum need for maintenance,
- that the coating system is maintenance friendly,
- that the coating system is application friendly,
- that health, safety and environmental impacts are evaluated and documented.

This NORSOK standard is not applicable to pipelines and pipeline risers.

## 2 Normative and informative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet the requirements of the referenced standards.

### 2.1 Normative references

ASTM D4752,	Standard Test Method for Measuring MEK Resistance of Ethyl Silicate (Inorganic) Zinc-Rich Primers by Solvent Rub
IMO MSC215(82),	Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-sided skin spaces of bulk carriers
ISO 1461,	Metallic coatings – Hot-dip galvanised coating on fabricated ferrous products – Requirements
ISO 2814,	Paints and varnishes – Comparison of contrast ratio (hiding power) of paint of the same type and colour
ISO 4624,	Paints and varnishes – Pull-off test for adhesion
ISO 4628-6,	Paints and varnishes – Evaluation of degradation of paint coatings – Designation of intensity, quantity and size of common types of defect – Part 6: Rating of degree of chalking by tape method
ISO 8501-1,	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings. Informative supplement to part 1: Representative photographic examples of the change of appearance imparted to steel when blast-cleaned with different abrasives (ISO 8501-1:1988/Suppl:1994)
ISO 8501-3,	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 3: Preparation grades of welds, edges and other areas with surface imperfections
ISO 8502-3,	Preparation of steel substrates before application of paints and related products – Test for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure sensitive tape method)
ISO 8502-6,	Preparation of steel substrates before application of paints and related products – Test for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method
ISO 8502-9,	Preparation of steel substrates before application of paints and related products – Test for the assessment of surface cleanliness – Part 9: Field method for the conductometric determination of water-soluble salts
ISO 8503,	Preparation of steel substrates before application of paints and related products – Surface roughness characteristics of blast cleaned substrates
ISO 8504-2,	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast cleaning
ISO 12944-4,	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 4: Types of surface and surface preparation
ISO 12944-5,	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 5: Protective paint systems
ISO 14919,	Thermal spraying — Wires, rods and cords for flame and arc spraying – Classification – Technical supply conditions
ISO 19840,	Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Measurement of, and acceptance criteria for, the thickness of dry film on rough surfaces
ISO 20340,	Paints and varnishes – Performance requirements for protective paint systems for offshore and related structures
ISO 29601,	Paints and varnishes – Corrosion protection by protective paint systems - Assessment of porosity in a dry film
NORSOK M-001,	Materials selection
NORSOK R-004,	Piping and equipment insulation
NORSOK S-002,	Working environment
NS 476,	Paints and coatings – Approval and certification of surface treatment inspectors
SFS 8145,	Anticorrosive painting, surface preparation methods of blast cleaned and shop primer coated steel substrates and preparation grades for respective treatments

## 2.2 Informative references

None

## 3 Terms, definitions and abbreviations

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

### 3.1 Terms and definitions

#### 3.1.1

##### **can**

verbal form used for statements of possibility and capability, whether material, physical or casual

#### 3.1.2

##### **coat-back**

continuation of passive fire protection along non fire critical steel work, from primary structural steel work, to reduce heat transfer

#### 3.1.3

##### **dry film thickness**

DFT

thickness of a coat or a coating system remaining on the surface after hardening

NOTE The DFT is measured in accordance with ISO 19840.

#### 3.1.3

##### **feathered**

gradual taper in thickness from a coated surface to an uncoated surface

#### 3.1.5

##### **holiday**

discontinuity in a coating, which exhibits electrical conductivity, when exposed to a specific voltage

#### 3.1.6

##### **maximum operating temperature**

maximum temperature including plant operation at unstable conditions

NOTE Unstable conditions include start-up/shutdown, control requirements and process upsets.

#### 3.1.7

##### **may**

verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

#### 3.1.8

##### **operating temperature**

temperature during normal operation, including normal variations

#### 3.1.9

##### **shall**

verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

#### 3.1.10

##### **shop primer**

thin protective coating normally applied for protection during transport and storage

**3.1.11****should**

verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

**3.1.12****stripe coat**

supplementary coat applied to ensure adequate protection of critical areas like edges, welds etc.

**3.2 Abbreviations**

ASTM	The American Society for Testing and Materials
CPS	coating procedure specification
CPT	coating procedure test
CSDS	coating system data sheet
DFT	dry film thickness
IMO	International Maritime Organization
ISO	International Organization for Standardization
ITP	inspection and test plan
MEK	methyl ethyl ketone
MSC	Maritime Safety Committee
NACE	National Association of Corrosion Engineers
NS	Norwegian Standard
OAR	Occupational Air Requirements
RAL	colour definitions issued by RAL (Deutsches Institut für Gütesicherung und Kennzeichnung e.V.)
RH	relative humidity
SCE	Standard Calomel Electrode
SFS	Finnish Standards Association
QC	quality control
VOC	volatile organic compound

**4 General requirements****4.1 General**

Selection of coating systems and application procedures shall be made with due consideration to conditions during fabrication, installation and service of the installation.

Specific qualification requirements for products, personnel and companies are given in clause 10.

**4.2 Planning**

All activities shall be fully incorporated in the fabrication plan.

Details of management, inspectors, operators, facilities, equipment and qualified procedures shall be established and documented before commencing work.

Steel surfaces shall be blast cleaned and coated (i.e. metal sprayed or coated with primer and the succeeding coat of the applicable coating system) prior to installation.

**4.3 Equipment protection and clean up**

All equipment and structures shall be fully protected from mechanical damages, ingress of abrasives and dust from blast cleaning. Sags, droplets and paint over-spray (inclusive dry-spray) shall be avoided. Adjacent areas not to be painted or already finished shall be protected. On completion of the work in any area, all masking materials, spent abrasives, equipment etc. shall be removed.

**4.4 Ambient conditions**

No final blast cleaning or coating application shall be done if the relative humidity is more than 85 % and when the steel temperature is less than 3 °C above the dew point. Coating shall only be applied or cured at ambient and steel temperatures above 0 °C.

The coating manufacturer shall specify the maximum and minimum application and curing temperature and other relevant limitations regarding application and curing conditions for each product in any coating system.

#### 4.5 Coating materials

The selected coating materials shall be suitable for the intended use and shall be selected after an evaluation of all relevant aspects such as

- corrosion protective properties,
- requirements to health, safety and environment,
- properties related to application conditions, equipment and personnel,
- experience with the coating materials and coating system,
- availability and economics of coating materials.

All coating materials and solvents shall be protected from ignition sources and shall remain within storage temperatures and storage conditions recommended by the coating manufacturer.

All coating materials and solvents shall be stored in the original container bearing the manufacturer's label and instructions. Each product shall have a batch number showing year and month of manufacture and giving full traceability of production. Shelf life shall be included in the technical data sheet.

Applicable coating systems are tabulated in Annex A.

Coating system no. 1, system no. 3B, system no. 4, system no. 5 and system no. 7 shall be pre-qualified in accordance with clause 10.

For those coating systems which are subject to pre-qualification, the specified coating systems are examples, and alternative coating systems may be used if the requirements of this NORSOK standard are fulfilled.

However, for coating system no. 1 and system no. 7 the number of coats and the coating film thicknesses given in Annex A are minimum requirements which shall apply for coating systems subject to pre-qualification testing.

Topcoat colours should be in accordance with Annex B. Light colours shall be used in ballast and fresh water tanks.

#### 4.6 Steel materials

Steel subject to surface preparation on site shall as a minimum requirement be in accordance with rust-grade B according to ISO 8501-1. Shop primers shall be regarded as temporary corrosion protection and shall be removed prior to the application of the coating systems herein unless the requirements in 4.7 are fulfilled.

#### 4.7 Shop primer

If a shop primer is considered left on the surface to form an integrated part of the final coating system, it shall be applied in accordance with the following:

- blast cleaning shall comply with ISO 8501-1 Sa 2½ and the surface shall remain at Sa 2½ until application of the primer. The primer shall consist of 1 coat zinc ethyl silicate primer with 15 µm thickness. Measured on a plane polished steel or glass test panel, the dry film thickness shall be maximum 25 µm.

Use of shop primer as an integrated part of the final coating system, can only be considered for coating system no. 1, system no. 3B, system no. 4, system no. 5, , system no. 7 and system no.8. For coating system 1, system no. 3B, system no. 4, system no. 5 and system no. 7, the pre-qualification requirements in 10.1 shall apply.

Areas with intact shop primer shall be sweep blasted to minimum lightly in accordance with SFS 8145; table 1, prior to application of the final coating system. All other areas shall be treated in accordance with the requirements for bare steel.

#### 4.8 Unpainted surfaces

The following items shall not be coated unless otherwise specified:

- aluminium, titanium, uninsulated stainless steel, insulated stainless steel heating/ventilation/air-conditioning ducts, chrome plated, nickel plated, copper, brass, lead, plastic or similar;
- jacketing materials on insulated surfaces.

If stainless steel is connected to carbon steel, the stainless steel part shall be coated 50 mm beyond the weld zone onto the stainless steel. For piping and pressure vessels, the coating for the stainless steel part shall not contain metallic zinc.

#### **4.9 Handling and shipping of coated items**

Degreased, blast cleaned or coated items shall be carefully handled to avoid contaminations or damage to the surfaces. No handling shall be performed before the coating system is cured to an acceptable level.

Packing, handling and storage facilities shall be of non-metallic type.

#### **4.10 Pre-qualification of products, personnel and procedures**

Pre-qualification requirements as described in clause 10 shall be fulfilled and documented prior to commencement of any work in accordance with this NORSOK standard.

#### **4.11 Metal coating**

Hot-dip galvanising shall be in accordance with ISO 1461. Minimum coating thickness for structural items and outfitting steel shall be 125 µm and 900 g/m<sup>2</sup>. Structural items shall be blast cleaned before hot-dip galvanising. When additional painting is specified, coating system no. 6 shall be used.

Metal spraying shall be in accordance with the requirements in this NORSOK standard.

#### **4.12 Records and reports**

All measurements and inspection results required by this NORSOK standard shall be recorded. The records shall provide traceability to the coated objects or associated parts of the coated objects and applied procedure (CPS) and qualification (CPT). All stages of the surface protection, pre-blasting operation, blasting and paint application shall be recorded in the painting report.

This includes

- all inspections and tests according to Table 3, including visual inspections and receive control at the paint shop,
- records of the thickness measurements, both average, minimum and maximum values and the number of measurements,
- percentage of thinner added to the paint,
- conditions during blasting, painting and curing,
- that the adhesion test shall be recorded according to ISO 4624,
- that the painting report shall include both required and obtained values,
- temperature during final curing when epoxy phenolic is used,
- curing test for zinc ethyl silicate, when used.

Defective work shall be reported and included in the records.

An example of painting report is given in Annex D.

Test reports shall be signed by the responsible inspector including title and inspector number.

#### **4.13 Additional requirements to equipment**

The following additional general requirements are applicable to surface protection of valves, actuators, gearboxes, pumps and motors:

- hand wheels and handles shall be in stainless steel or hot dip galvanised carbon steel according to ISO 1461;
- all bolt holes, not suitable for coating, shall as a minimum requirement, be preserved with wax. Unused treaded bolt holes, etc. shall be plugged or sealed.

Signs shall be fastened after painting operations are finished and the paint system is ready for handling.

Welds shall be continuous. Tack welding is not accepted.

Voids that cannot be blast cleaned and painted shall be closed.

All exposed surfaces on valves and flanges shall be blast cleaned and painted up to raised face or gasket area.

Care shall be made to prevent blasting or painting of any stem, valve stem tread, packing, packing nuts and bolts or other items which in normal operation are subject to frequent usage. Precautions shall be made to protect the bolts and nuts during the blasting and painting operations.

When coating system no. 2A or system no. 2B is required, equipment skids or other structures shall be designed in such a way that metalizing is possible.

## **5 Health, safety and environment**

The following documentation shall be provided and used when evaluating coating systems:

- chemical name of organic solvent, occupational air requirements (OAR) number according to Norwegian regulations, and volatile organic components content (VOC) in g/l;
- percentage of low molecular epoxy (molecular weight < 700);
- content of hazardous substances, see NORSOK S-002;
- specification of hazardous thermal degradation components;
- combustibility;
- special handling precautions and personal protection.

All coating products shall as a minimum be in accordance with relevant Norwegian regulatory requirements regardless of where the coating operation takes place.

Content of silica and heavy metals in blast cleaning media (see ISO 8504-2) shall be given.

## **6 Surface preparation**

### **6.1 Pre-blasting preparations**

Sharp edges, fillets, corners and welds shall be rounded or smoothed by grinding to grade P3 as defined in ISO 8501-3 (minimum radius 2 mm).

Hard surface layers (e.g. resulting from flame cutting) shall be removed by grinding prior to blast cleaning.

The surfaces shall be free from any foreign matter such as weld flux, residue, slivers, oil, grease, salt etc. prior to blast cleaning. All surfaces should be washed with clean fresh water prior to blast cleaning.

All machined parts shall be cleaned with a solvent liquid suitable to remove any machining fluids.

Any oil and grease contamination shall be removed in accordance with ISO 12944-4, prior to blasting operations.

Any major surface defects, particularly surface laminations or scabs detrimental to the protective coating system shall be removed by suitable dressing. Where such defects have been revealed during blast cleaning, and dressing has been performed, the dressed area shall be re-blasted to the specified standard.

All welds shall be inspected and, if necessary, repaired prior to final blast cleaning of the area. Surface pores, cavities etc. shall be removed by suitable dressing or weld repair.

### **6.2 Blast cleaning**

Blasting abrasives shall be dry, clean and free from contaminants, which will be detrimental to the performance of the coating.

Size of abrasive particles for blast cleaning shall be such that the prepared surface profile height (anchor pattern profile) is in accordance with the requirements for the applicable coating system. The surface profile shall be graded in accordance with ISO 8503. Grit shall be used as blast medium. The grit shall be non-metallic and free from chlorides when used on stainless steel substrates.

The cleanliness of the blast cleaned surface shall be as referred to for each coating system in accordance with ISO 8501-1.

### **6.3 Final surface condition**

The surface to be coated shall be clean, dry, free from oil/grease, and have the specified roughness and cleanliness until the first coat is applied.

Dust, blast abrasives etc. shall be removed from the surface after blast cleaning such that the particle quantity and particle size do not exceed rating 2 of ISO 8502-3.

The maximum content of soluble impurities on the blasted surface as sampled using ISO 8502-6 and distilled water, shall not exceed a conductivity measured in accordance with ISO 8502-9 corresponding to a NaCl content of 20 mg/m<sup>2</sup>.

## **7 Paint application**

### **7.1 General**

Contrasting colours shall be used for each coat of paint.

Hiding power of topcoat for specified colours shall be tested in accordance with ISO 2814. Contrast ratio shall not be less than 94 % at the specified topcoat thickness.

The coating manufacturer shall provide a CSDS for each coating system to be used, containing at least the following information for each product:

- surface pre-treatment requirements;
- film thickness (maximum, minimum and specified);
- maximum and minimum re-coating intervals at relevant temperatures;
- final curing time at relevant temperatures;
- information on thinners to be used (quantities and type);
- coating repair system (qualified in accordance with Table 1).

### **7.2 Application equipment**

The method of application shall be governed by the coating manufacturer's recommendation for the particular coating being applied.

Roller application of the first primer coat is not acceptable. When paints are applied by brush, the brush shall be of a style and quality acceptable to the coating manufacturer. Brush application shall be done so that a smooth coat, as uniform in thickness as possible, is obtained.

### **7.3 Application**

For each coat, a stripe coat shall be applied by brush to all welds, corners, behind angles, edges of beams etc. and areas not fully reachable by spray in order to obtain the specified coverage and thickness.

Edges of existing coating shall be feathered towards the substrate prior to overcoating.

Each coat shall be applied uniformly over the entire surface. Skips, runs, sags and drips shall be avoided. Each coat shall be free from pinholes, blisters and holidays.

Contamination of painted surfaces between coats shall be avoided. Any contamination shall be removed.

## **8 Thermally sprayed metallic coatings**

### **8.1 General**

Relevant requirements provided in this NORSOK standard are applicable for thermally sprayed metallic coatings. Specific requirements valid for thermally sprayed metallic coatings are provided in 8.2 to 8.4.

### **8.2 Coating materials**

The materials for metal spraying shall be in accordance with the following:

Aluminium: Type Al 99.5 of ISO 14919 or equivalent.

Aluminium alloy: Aluminium alloy with 5 % Mg, type AlMg5 of ISO 14919 or equivalent.

Zinc or alloys of zinc.

All coating metals shall be supplied with product data sheets and quality control certificates, and be marked with coating metal manufacturer's name, manufacturing standard, metal composition, weight and manufacture date.

Metal coating shall be sealed or overcoated as specified in coating system no. 2 in Annex A.

Maximum operating temperature when zinc or alloys of zinc metal coating is used is 120 °C for uninsulated surfaces. For insulated surfaces, the maximum temperature is 60 °C.

### **8.3 Application of thermally sprayed coating**

Each coat shall be applied uniformly over the entire surface. The coat shall be applied in multiple layers and shall overlap on each pass of the gun.

The coating shall be firmly adherent. The surface after spraying shall be uniform and free of lumps, loosely adherent spattered metal, bubbles, ash formation, defects and uncoated spots.

Before application of any further coat, any damage to the previous coat shall be repaired.

### **8.4 Repair, field coating of pipes and coating of in-fill steel**

All requirements, including adhesion, applicable to metal spraying, shall apply.

The treating and handling of the substrate shall be done in such a manner that the product in its final condition will have a continuous and uniform coating.

Before the metal spraying operation starts, the area 30 cm to 40 cm in distance from the weld zone shall be sweep-blasted to ensure that all contamination is removed. The uncoated welding zone shall be blast cleaned as specified for coating system no. 2. The metal coating shall be performed according to 8.3.

## **9 Sprayed on passive fire protection**

### **9.1 General**

Relevant requirements provided in this NORSOK standard are applicable for sprayed on passive fire protection. Specific requirements valid for sprayed on passive fire protection are provided in 9.2 to 9.4.

Information regarding selection of materials, thicknesses and areas to be protected is not covered by this NORSOK standard, but the passive fire protective material shall follow applicable requirements to fire protective properties.

### **9.2 Materials**

The sprayed on fire protection shall be applied with wire mesh reinforcement or fibre mesh.

Where wire mesh is used, it shall be mechanically fixed to the steel substrate by studs and be properly embedded into the passive fire protection material. For epoxy based materials the wire mesh shall be of hot dip galvanised steel or stainless steel. The steel wire mesh shall be plastic coated for all other types of fire protection.

The principles for accepting fibre mesh is that the mesh is applied around the whole member, such that the fibre mesh overlaps itself and is thereby locked. This needs particular attention at the earliest point in the design phase. Reinforcement and anchoring of the sprayed on fire protection using fibre mesh may be used for piping, tubulars, rectangulars, girders and minor supports or similar within the limits listed below:

- rectangular structural members with width 800 mm or less;
- tubular structural members or pipes with diameter 900 mm or less;
- I-girders and T-girders with height up to 700 mm;
- angular profiles with height/width less than 200 mm.

Provided protective properties and long term integrity are documented and agreed by the purchaser, fibre mesh may be used on larger sections.

In the event the spray-on passive fire protection is not applied around the I-girders and T-girders, but terminated onto a plate field, fibre mesh may be accepted provided the termination onto the plate field is equal to the agreed coat-back length, commonly taken as 450 mm from the girder, and provided the edge of the fire protective coating is reinforced and anchored using wire mesh and studs.

In all cases, it is a prerequisite that the supplier of the sprayed on passive fire protection has certified the products in compliance with regulatory requirements and with the applied application and reinforcement method.

Cement based fire protection shall be externally protected with a material which retards/stops the migration of carbon dioxide and humidity. The coating shall be accepted by the manufacturer.

Coating system no. 5 shall be used for sprayed on passive fire protection. An epoxy tie-coat shall be applied on top of the epoxy based fire protection prior to application of the topcoat. Topcoats used on passive fire protection shall be pre-qualified for coating system no. 1. The sprayed on passive fire protection coating system without topcoat shall be pre-qualified in accordance with clause 10.

During construction, other primers/substrates than the ones used in the pre-qualification test for the passive fire protection system may be used, provided the products are already pre-qualified in coating system no. 1.

Under all conditions, surface preparation, primers/substrates and topcoats are subject to acceptance by the manufacturer of sprayed on passive fire protective coating.

The supplier of the sprayed on passive fire protection material shall document that the passive fire protection system as applied has good properties concerning relevant rapid temperature changes during construction and operation.

### **9.3 Application**

Application of the sprayed on passive fire protective coating shall be in accordance with the recommendations given by the manufacturer of the material.

Studs shall be welded to the structural members, firewalls and fire rated decks with a maximum of 300 mm centres. Attention shall be paid to areas where mesh ends on the substrate. In these areas the maximum distance shall be 200 mm between welded studs.

On highly stressed structural steel, stud welding may not be allowed. In these areas, the studs may be glued to the substrate or fibre mesh may be used.

If several layers of passive fire protective coating are necessary, the material shall normally be sprayed wet to wet.

After the passive fire protective coating material has cured, and before application of topcoat, the thickness of the coating shall be checked. Holes shall be drilled down to the substrate on a spot check basis to measure that the thickness is correct. The holes shall be marked and filled with fresh material immediately after the readings. Where feasible, non-destructive techniques may be used as an alternative to verify the thickness of the coating.

Topcoating shall be carried out in accordance with manufacturer's specification.

The surface finish shall conform to the reference sample prepared during the CPT (see 10.3) and manufacturers application guide. On horizontal surfaces and cavities, adequate water drainage shall be ensured. Areas, which are difficult to access for spraying of passive fire protective coating, shall to the extent possible, be boxed in before the passive fire protective coating is applied. Adequate water shedding shall be arranged for.

## 9.4 Repairs

The damaged area shall be removed and the edge around the area shall be cut back to solid materials.

Adequate overlap with existing reinforcement shall be ensured. If the area is greater than 0,025 m<sup>2</sup>, the mesh shall be replaced and secured to the substrate. If the corrosion protection is damaged, the area shall be blast cleaned to Sa 2½ and new corrosion protection applied.

## 10 Qualification requirements

### 10.1 Pre-qualification of products

The requirements for pre-qualification prior to use are applicable to coating system no.1 (applied on carbon steel) and to coating system no. 3B, system no. 4 and system no. 7. In addition, any sprayed on fire protective coating to be used for outdoor or naturally ventilated areas shall be subject to pre-qualification testing. For system no. 7C the coating is pre-qualified up to the test temperature (steel temperature). The pre-qualification report must state the steel test temperature.

Acceptance criteria in the pre-qualification testing are considered as minimum performance requirements. Pre-qualification of products shall be carried out by an independent laboratory. Coating of the test panels shall be controlled by the independent laboratory.

Unless otherwise specified, pre-qualifications carried out according to earlier editions of this NORSOK standard are valid provided the coating system fulfils all other requirement in this edition and provided such pre-qualification testing was started before this edition was issued.

If agreed by the purchaser, the approved topcoat in a pre-qualified coating system, may substitute another pre-qualified topcoat, provided the intermediate coating is the same and the film-thickness of the topcoats are equal.

When a shop primer is an integrated part of coating system no.1, system no. 3B or system no. 7, the following shall apply:

- one coating system (system no. 1, system no. 3B or system no.7) shall be tested with and without the shop-primer. Both systems shall pass the test in Table 1;
- the shop primer may then be used as an integrated part of a compatible coating system which has been pre-qualified in accordance with Table 1 with or without shop primer.

To form an integrated part of coating system no. 4 and system no. 5, the complete coating system with shop primer shall be pre-qualified according to Table 1.

**Table 1 - Pre-qualification tests for coating materials**

Test	Acceptance criteria
<p><b>Seawater immersion according to ISO 20340</b></p> <p>Testing is required for the following coating systems:</p> <ul style="list-style-type: none"> <li>coating system no. 3B and system no. 7A, system no. B and system no. C;</li> <li>coating system no. 1 when used in tidal or splash zones.</li> </ul>	<p>According to ISO 20340.</p>
<p><b>Ageing resistance according to ISO 20340, procedure A</b></p> <p>Testing is required for the following coating systems:</p> <ul style="list-style-type: none"> <li>coating system no. 1, system no. 3B, system no. 4, system no. 5A and system no. B;</li> <li>coating system no. 7A</li> </ul>	<p>According to ISO 20340.</p> <p>Supplementary requirements:</p> <ol style="list-style-type: none"> <li>Chalking (see ISO 4628-6): Maximum rating 2. Applicable to coating system no. 1 only.</li> <li>Adhesion (see ISO 4624): Minimum 5,0 MPa and maximum 50 % reduction from original value.</li> <li>Overcoatable without mechanical treatment obtaining minimum adhesion of 5,0 MPa.</li> <li>Pull-off testing (see ISO 4624) for coating system no. 5A and system no. 5B: Maximum 50 % reduction from original value, minimum 2,0 MPa for cement based products and minimum 3,0 MPa for epoxy based products.</li> <li>Water absorption after complete ageing resistance test shall be reported for coating system no. 5A.</li> </ol>
<p>Cathodic disbonding for systems operating at temperature <math>\leq 50</math> °C, according to ISO 20340</p> <p>Coating system no. 3B and system no. 7A, system no. B and system no. C</p> <p>Coating system no. 1 when used in tidal or splash zones.</p>	<p>According to ISO 20340.</p>
<p>Additional testing of cathodic disbonding for systems operating at temperature <math>&gt; 50</math> °C</p> <p>Coating system no. 7C</p> <p>Steel temperature: Maximum operating steel temperature</p> <p>Electrolyte: 3,5 % NaCl</p> <p>Electrolyte temperature: 30 °C</p> <p>Potential: -1.2 V SCE</p> <p>Oxygen concentration: <math>8 \times 10^{-6}</math></p> <p>Diameter circular coating holiday: 6 mm</p> <p>Duration: 4 weeks</p>	<p>According to ISO 20340.</p>
<p>NOTE 1 Acceptance criteria are considered as minimum performance requirements.</p> <p>NOTE 2 Adhesion testing shall be performed by using equipment with an automatically centred pulling force. For coating system no. 4, adhesion testing may be conducted on coating without non-skid aggregates on test panels not exposed to the above test environments.</p> <p>NOTE 3 Coating system no. 3B for ballast water tanks approved to IMO MSC.215 (82) shall be considered as qualified (alternative testing referred to in IMO MSC.215 (82) is not accepted).</p> <p>NOTE 4 The thickness of coating system no. 5A to be tested shall be 6 mm.</p> <p>NOTE 5 Corrosion tests on coating system no. 5A and system no. 5B shall be performed on material without reinforcement.</p> <p>NOTE 6 Tests on coating system no. 5A and system no. 5B shall be carried out on system without topcoat.</p> <p>NOTE 7 Cathodic disbonding tests with steel temperature above 100 °C: The electrolyte shall be pressurized to increase boiling point above steel temperature to avoid evaporation of the electrolyte.</p> <p>NOTE 8 Qualification of coating system no 7 shall be done on carbon steel. The coating system is then also qualified for stainless steel.</p>	

Fire testing after ageing shall be performed for epoxy based sprayed on passive fire protection systems. Four test panels with minimum dimensions 300 mm x 300 mm shall be prepared in accordance with 9.2, 9.3 and Table 1. Tested coating may be with or without reinforcement. Two test panels shall be tested for ageing resistance in compliance with ISO 20340, procedure A. The other two panels shall be kept as reference.

None of the panels shall have scribes. Minimum one test panel that has been subject to ageing testing and one reference test panel shall be fire tested in compliance with the requirements for hydrocarbon fire.

Maximum 10 % increase in mean temperature read as °C of the aged test panel as compared to the simultaneously tested reference panel is accepted. This requirement refers to the recorded mean temperature increase from the two panels when fire tested for 60 min or when the panel exceeds 400 °C within 60 min of the fire test.

## 10.2 Qualification of companies and personnel

### 10.2.1 Companies

Companies performing work in accordance with this NORSOK standard shall document experience in organizing, planning and execution of work with similar size and complexity.

### 10.2.2 Qualification of paint operators

Operators shall be qualified to tradesman level as blast-cleaner, painter, applicator etc. The personnel shall have relevant knowledge of health and safety hazard, use of protection equipment, coating materials, mixing and thinning of coatings, coating pot-life, surface requirements etc.

Personnel not qualified to tradesman level, shall document training and experience to the same level as a formalized tradesman education.

### 10.2.3 Qualification of metal spray operators

Prior to commencement of work in accordance with this NORSOK standard, the operator shall pass the pre-qualification test described in Table 2. The results from the qualification test are valid for maximum 12 months without regular coating work.

**Table 2 - Qualification of metal spraying**

Test	Acceptance criteria
<b>Visual examination of coating</b> All test panels shall be examined without magnification and with 10X magnification.	See 8.3.
<b>Film thickness and shape test</b> (see NOTE 2)	Minimum 200 µm on all specimen surfaces (ISO 19840).
<b>Adhesion</b> (see NOTE 3) ISO 4624. All test panels shall be tested. Examination of the test specimens shall be conducted after rupture to determine the cause of failure.	No single measurement less than 9,0 MPa. Re-testing is required if the failure occurred at the adhesive/coating interface. Test equipment with an automatic centred pulling force shall be used.
NOTE 1	<u>General</u> : Test materials shall be of a comparable grade to be used in production. The coating shall be applied in accordance with this NORSOK standard and the proposed procedure.
NOTE 2	<u>Specimens for shape test</u> : One 1500 mm long "T", "I" or "H" shaped profile approximately dimensions 750 mm high and 13 mm thick. Another specimen shall be cut from a 1500 mm long 50 mm diameter pipe.
NOTE 3	<u>Specimens for adhesion test</u> : Five specimens for the adhesion test shall be prepared according to the requirements of ISO 4624 using minimum 5 mm thick panels.

### 10.2.4 Qualification of passive fire protection operators

Operators, including pump machine operator, shall be qualified, trained and certified according to the manufacturer's procedures.

Before any stud welding, the welders and the procedures to be used shall be qualified in accordance with the coating manufacturer's procedures.

If the operators or stud welders have not been working with the type of application or material within a period of 12 months, the applicator shall document that necessary supplementary training have been given before start of any work.

### **10.2.5 Qualification of supervisors, foremen and QC personnel**

Personnel carrying out inspection or verification shall be qualified in accordance with NS 476, Inspector level III, certified as NACE coating inspector level III or ICorr inspector level III.

Inspectors according to NS 476, Inspector level II, may carry out the inspection work under the supervision of an inspector level III.

Supervisors and foremen shall be qualified to tradesman level and should be qualified in accordance with NS 476, Inspector level II, or NACE level II.

Supervisors, foremen or QC personnel involved in application of passive fire protection shall in addition, be trained and certified according to the procedures of the manufacturer of the passive fire protective material.

## **10.3 Qualification of procedures**

### **10.3.1 Coating procedure specification (CPS)**

A detailed CPS based on the requirements of this NORSOK standard shall be established. The CPS shall be prepared by the application contractor and contain the following:

- step by step information of the process (receive control, cleaning, blasting, coating and QC);
- identification of equipment for surface preparation and application;
- information given on CSDS;
- personal protective equipment to be used;
- safety data sheets for each product;
- product data sheets;
- example of paint report;
- repair procedure.

For the sprayed on passive fire protection, the CPS shall, in addition, contain information regarding maximum allowable time between application of the different layers, method and frequency of measuring thicknesses, location of the reinforcement related to the different thicknesses and restrictions for use of solvents.

The qualified CPS shall be followed during all coating work.

The following changes in the coating application parameters require the CPS to be re-qualified:

- any change of coating material;
- change of method and equipment for surface preparation and coating application.

The CPS shall be written in both English and in the first language for the paint operators. There shall only be one document.

### **10.3.2 Coating procedure test (CPT)**

A CPT shall be used to qualify all coating procedures. A suitable location on the component to be coated may be selected on which the CPT shall be carried out. Alternatively, a test panel in accordance with 10.2.3 may be used for metal spraying and a test panel (minimum 1 m x 1 m) containing at least 1 pipe-end, 2 pipes, 1 angle and 1 flat bar may be used for other coating systems.

The coating procedures shall be qualified under realistic conditions likely to be present during coating application.

If the shop primer is intended to form an integrated part of the final coating system, and the requirements of 4.7 and 10.1 are fulfilled, the CPT shall be conducted on shop primed steel sweep blasted to grade lightly or

more in accordance with SFS 8145 and on steel blast cleaned to the agreed standard for steel without shop primer.

Inspection and testing requirements for the CPT, including acceptance criteria, shall be as given in clause 11. For metal spray, additional acceptance criteria provided in Table 2 shall also apply.

Curing time prior to carry out the adhesion test shall be according to time for fully cured in coating supplier's data sheet.

For sprayed on passive fire protection, the CPT shall be performed on an area accepted by the parties involved. The area shall be clearly marked, and will serve as a reference area throughout the project. The application of the fire protection shall comply with the applicable procedures, and be subject to approval by the parties involved. The surface finish on the CPT area, and quality of the work, shall be used as a reference with respect to the quality of the work to be done during further production work.

Coating procedure tests approved within the last 3 years for previous projects or supplies and used within the last year may be used provided they comply with the above requirements.

## 11 Inspection and testing

Testing and inspection shall be carried out in accordance with Table 3. Surfaces shall be accessible until final inspection is carried out.

**Table 3 - Inspection and testing**

Test type	Method	Frequency	Acceptance criteria	Consequence
Environmental conditions	Ambient and steel temperature. Relative humidity. Dew point.	Before start of each shift + minimum twice per shift.	In accordance with specified requirements	No blasting or coating
Visual examination	Visual for sharp edges weld spatter slivers, rust grade, etc. ISO 8501-3	100 % of all surfaces	No defects, see specified requirements	Defects to be repaired
Cleanliness	a) ISO 8501-1 b) ISO 8502-3	a) 100 % visual of all surfaces b) Spot checks	a) In accordance with specified requirements b) Maximum quantity and size rating 2	a) Reblasting b) Recleaning and retesting until acceptable
Salt test	ISO 8502-6 and ISO 8502-9	Spot checks	Maximum conductivity corresponding to 20 mg/m <sup>2</sup> NaCl	Repeated washing with potable water and retesting until acceptable
Roughness	Comparator, stylus instrument or testex tape (see ISO 8503)	Each component or once per 10 m <sup>2</sup>	As specified	Reblasting
Curing test (for Zn silicate).	ASTM D4752	Each component or once per 100 m <sup>2</sup>	Rating 4 to 5	Allow to cure
Visual examination of coating	Visual to determine curing, contamination, solvent retention, pinholes/popping, sagging and surface defects	100 % of surface after each coat	According to specified requirements	Repair of defects
Holiday detection	ISO 29601. Voltage, see table 1	As per coating system specification	No holidays	Repair and retesting.
Film thickness	ISO 19840. Calibration on a smooth surface	ISO 19840	ISO 19840, and coating system data sheet	Repair, additional coats or recoating as appropriate
Adhesion	ISO 4624, using equipment with an automatic centred pulling force, and carried out when coating system are fully cured	Spot checks	See notes below	Coating to be rejected

- NOTE 1 For coating system no. 2 A, adhesion during CPT shall be minimum 9,0 MPa. Adhesion measured during production shall be minimum 7,0 MPa for any single measurement.
- NOTE 2 For coating system no. 3A, system no. 3C, system no. 3D, system no. 3E, system no. 3F and system no. 3G, maximum 30 % reduction from the CPT is acceptable. Absolute minimum value is 5 MPa.
- NOTE 3 For sprayed on passive fire protection, maximum 50 % reduction from CPT value read as cohesion is acceptable. Absolute minimum values are 2,0 MPa for cement based products and 5,0 MPa for epoxy based products. Epoxy based passive fire protection may be used to glue the test dollies to the primer in order to measure the adhesive strength.
- NOTE 4 For the remaining coating systems, 50 % reduction of average adhesion value from the CPT is acceptable as minimum adhesion during production coating. Absolute minimum value is 5 MPa.
- NOTE 5 For adhesion test during CPT, glue failure with values below 15 MPa is not accepted. X-cut test can be used as a supplementary test for adhesion, when relevant.
- NOTE 6 Spot checks shall be defined and agreed on before start of each project and included in the inspection and test plan (ITP).

## Annex A (Normative) Coating systems

### A.1 Coating system no. 1 (shall be pre-qualified)

Application (if not specified under others)	Surface preparation	Coating system	Minimum DFT µm
Carbon steel with maximum operating temperature < 120 °C – Structural steel – Exteriors of equipment, vessels, piping and valves (not insulated)	Cleanliness: ISO 8501-1 Sa 2½	1 coat zinc rich primer:	60
	Roughness: ISO 8503 Grade Medium G (50 µm to 85 µm, R <sub>v5</sub> )	Minimum number of coats: 3 Minimum DFT of complete coating system:	280
<p>NOTE 1 If the second coat is not applied immediately after a zinc rich primer has cured, or if the primer is exposed to humid or outdoor conditions prior to application of the second coat, a tie-coat/sealer shall be applied on top of the primer immediately after the primer has cured to prevent oxidation of the zinc. This tie-coat/sealer shall either be of a thickness below 50 µm or prequalified as a part of the coating system.</p> <p>NOTE 2 When this coating system is used for accessible deck areas, a non-skid aggregate shall be added to the second last coat. Prior to applying the coating where the non-skid aggregates are added, the primer and the succeeding coat(s) shall be applied to a minimum DFT of 175 µm and fully cured.</p> <p>NOTE 3 Chalking rating 1 (see Table 1) or better should be preferred for externally exposed surfaces.</p> <p>NOTE 4 For the splash zone area, the coating system shall also fulfil the pre-qualification requirements for coating system no. 7.</p> <p>NOTE 5 Zinc rich primer shall be in accordance with ISO 12944-5.</p> <p>NOTE 6 Specialized coating systems with at least two coats and without zinc rich primers, may be selected for particularly exposed areas on installations provided the coating system is pre-qualified in accordance with 10.1, the coating thickness is ≥ 1000 µm DFT and provided relevant successful field experience is documented.</p>			

## A.2 Coating system no. 2

Application (if not specified under others)	Surface preparation	Coating system	Minimum DFT µm
Coating system no. 2A shall be used for all carbon steel surfaces exposed to operating temperature > 120 °C.		<b>System no. 2A:</b> Thermally sprayed aluminium or alloys of aluminium.	200
Coating system no. 2A or system no. 2B shall be used for the below carbon steel objects: – All insulated surfaces of tanks, vessels, piping. – Flare booms and crane booms.	Cleanliness: ISO 8501-1 Sa 2½	Sealer:	For sealer, see NOTE 1.
Underside of bottom deck included piping, jacket above splash zone lifeboat stations are optional areas (to be decided in each project).	Roughness: ISO 8503 Grade Medium G (50 µm to 85 µm, R <sub>y5</sub> )	<b>System no. 2B:</b> Thermally sprayed zinc or alloys of zinc:  Tie coat:  Intermediate coat: Topcoat:	100  For tie coat, see NOTE 2. 125 75
<p>NOTE 1 The following is applicable to coating system no. 2A only: All metallized surfaces shall be sealed in accordance with the following requirements: The sealer shall fill the metal pores. It shall be applied until absorption is complete. There should not be a measurable overlay of sealer on the metallic coating after application. The materials for sealing the metal coating shall be two-component epoxy for operating temperatures below 120 °C and aluminium silicone above 120 °C.</p> <p>NOTE 2 The following is applicable to coating system no. 2B only: The intermediate coat and the topcoat shall have been pre-qualified as coating system no. 1. The pre-qualification may have been carried out at different film thicknesses. A tie coat shall normally be used unless demonstrated not to be beneficial to the overall performance. The tie-coat shall be in accordance with manufacturer's recommendation.</p> <p>NOTE 3 For items that will be welded after coating, 5 cm to 10 cm measured from the bevel area shall be left uncoated and 30 cm to 40 cm measured from the bevel area shall be left without coating on top of the metal coating.</p> <p>NOTE 4 For insulated piping and equipment operating at &lt; 120 °C, coating system no. 9 may be selected.</p> <p>NOTE 5 The part of pipes that penetrates an insulated pipe penetration shall be coated according to coating requirements for insulated pipes. The coated area shall include the pipe-penetration and 0,5 m on each side.</p> <p>NOTE 6 When perforated guards are used for personnel protection (NORSOK R-004 Insulation class 3 with T &lt; 150 °C), coating system to be selected as for un-insulated pipes and vessels.</p>			

**A.3 Coating system no. 3 (system no. 3B shall be pre-qualified)**

Application (if not specified under others)	Surface preparation	Coating system
<p>Internal surface of carbon steel tanks</p> <p><b>Coating system no. 3A</b> Potable water tanks</p> <p><b>Coating system no. 3B</b> Ballast water tanks/internal seawater filled compartments</p> <p><b>Coating system no. 3C</b> Tanks for stabilised crude, diesel and condensate</p> <p><b>Coating system no. 3D</b> Process vessels &lt; 0,3 MPa &lt; 75 °C</p> <p><b>Coating system no. 3E</b> Process vessels &lt; 7,0 MPa &lt; 80 °C</p> <p><b>Coating system no. 3F</b> Process vessels &lt; 3,0 MPa &lt; 130 °C</p> <p><b>Coating system no. 3G</b> Vessels for storage of methanol, mono ethyl glycol etc.</p>	<p><u>Coating system no. 3A:</u> Cleanliness: ISO 8501-1 Sa 2½ Roughness: ISO 8503 Grade Medium G (50 µm to 85 µm, R<sub>v5</sub>)</p> <p><u>Coating system no. 3B:</u> According to pre-qualification</p> <p><u>Other coating systems:</u> As for coating system no. 3A or according to coating manufacturers recommendation.</p>	<p>Lining materials for carbon steel tanks are subject to special evaluation, and shall always be approved by the purchaser.</p> <p>As a minimum the following shall be evaluated:</p> <ul style="list-style-type: none"> <li>• medium;</li> <li>• operating temperature;</li> <li>• operating pressure;</li> <li>• experience with product;</li> <li>• properties with respect to explosive decompression.</li> </ul>
<p><b>General notes:</b></p> <p>NOTE 1 100 % holiday inspection in accordance with ISO 29601 (Table 1) is required for all tanks, except for coating system no. 3B and system no. 3C where the tank tops and upper 1 m of walls shall be inspected. Coating system no. 3G shall not be holiday tested.</p> <p>NOTE 2 Adhesion test shall be carried out on separate test panels, inimum adhesion values in accordance with ISO 4624 shall be 5,0 MPa when using automatically centred test equipment.</p> <p>NOTE 3 When solvent based coating is used, the maximum coating thickness given on the paint manufacturer's technical data sheet shall not be exceeded.</p> <p>NOTE 4 External of lined vessel shall be marked clearly in black letters: LINED VESSEL, NO HOT WORK</p> <p><b>Specific notes:</b></p> <p><u>Coating system no. 3A:</u> NOTE 1 All products used internally in potable water tanks and fresh water tanks shall be approved for such use by end users' governing requirements/local authorities, e.g. The Norwegian health authorities. NOTE 2 Internal lining to be applied in minimum two coats solvent free epoxy each 300 µm.</p> <p><u>Coating system no. 3B:</u> NOTE 1 Internal lining to be applied in minimum two coats. NOTE 2 The coating system is subject to pre-qualification in accordance with Table 1. NOTE 3 Coating system no. 3B for ballast water tanks approved to IMO MSC.215(82) shall be considered as qualified (alternative testing referred to in IMO MSC.215(82) is not accepted).</p> <p><u>Coating system no. 3C:</u> System to be applied to the flat bottoms and lower 1 m of walls, and to the roofs and upper 1 m of walls.</p> <p><u>Coating system no. 3D:</u> NOTE 1 2-component solvent free or solvent based epoxy is recommended. NOTE 2 The coating should be cured as close to operating temperature as possible.</p> <p><u>Coating system no. 3E:</u> 2-component solvent based or solvent free epoxy or modified novolac epoxy is recommended.</p> <p><u>Coating system no. 3F:</u> 2-component solvent free novolac epoxy is recommended.</p> <p><u>Coating system no. 3G:</u> Zinc ethyl silicate to be used DFT 50 µm to DFT 90 µm, or in accordance with manufacturer's technical data sheet.</p>		

**A.4 Coating system no. 4 (shall be pre-qualified)**

Application (if not specified under others)	Surface preparation	Coating system (example)	DFT µm
Walkways, escape routes and lay down areas.  Coating system no. 1 may be used on other deck areas.	Cleanliness: ISO 8501-1 Sa 2½  Roughness: ISO 8503 Grade Medium G (50 µm to 85 µm, R <sub>v5</sub> )	Non-skid epoxy screed	3000
NOTE 1 Light colour non-skid aggregates shall be used. NOTE 2 Particle size of non-skid aggregate to be 1 mm to 5 mm. NOTE 3 Aggregates shall have a uniform spread. NOTE 4 Coating systems for escape route and lay down areas shall have adequate properties related to water absorption, impact resistance, coefficient of friction, hardness and flexibility.			

**A.5 Coating system no. 5****A.5.1 Coating system no. 5A (shall be pre-qualified)**

Application (if not specified under others)	Surface preparation	Coating system	DFT µm
Epoxy based fire protection.	Cleanliness: ISO 8501-1 Sa 2½  Roughness: ISO 8503 Grade Medium G (50 µm to 85 µm, R <sub>y5</sub> )	1 coat epoxy primer: or 1 coat zinc rich epoxy: <u>1 x epoxy tie coat:</u> Minimum DFT of complete primer system: Followed by: Epoxy based fire protection	50  60 <u>25</u>  85
NOTE 1 Stud welding shall be done before final blast cleaning. NOTE 2 If the passive fire protection material is not applied immediately after the primer has cured, or if the primer is exposed to humid or outdoor conditions prior to application of the passive fire protection material, coating alternative 2) shall be used. NOTE 3 Coating system no. 2B (without intermediate and topcoat) may be used as substrate for epoxy based passive fire protection, provided this is approved by the manufacturer of the passive fire protection coating. NOTE 4 The coating system and products shall be approved by the manufacturer of the passive fire protection coating. NOTE 5 An epoxy tie coat shall be applied on top of the epoxy based fire protection prior to applying the top coat. NOTE 6 Topcoating on top of the passive fire protection shall be in accordance with the passive fire protection manufacturer's recommendation.			

**A.5.2 Coating system no. 5B (shall be pre-qualified)**

Application (if not specified under others)	Surface preparation	Coating system	DFT µm
Cement based fire protection.	Cleanliness: ISO 8501-1 Sa 2½  Roughness: ISO 8503 Grade Medium G (50 µm to 85 µm, R <sub>y5</sub> )	1 coat zinc rich epoxy:  <u>1 coat two component epoxy:</u>  Minimum DFT(µm) of complete coating system: Followed by: Cement based fire protection	60  <u>200</u>  260
NOTE 1 Stud welding shall be done before final blast cleaning. NOTE 2 If the epoxy is not applied immediately after the primer has cured, or if the primer is exposed to humid or outdoor conditions prior to application of the epoxy, a tie coat shall be applied on top of the zinc rich epoxy primer immediately after the primer has cured. NOTE 3 The 200 µm epoxy may be applied as 2 x 100 µm. NOTE 4 The coating system and products shall be approved by the manufacturer of the passive fire protection coating. NOTE 5 Topcoating on top of the passive fire protection shall be in accordance with the passive fire protection manufacturer's recommendation.			

**A.6 Coating system no. 6**

Application (if not specified under others)	Surface preparation	Coating system	DFT µm
<b>Coating system no. 6A:</b> Un-insulated stainless steel when painting is required.  Aluminium when painting is required.	Sweep blasting with non-metallic and chloride free grit to obtain anchor profile of approximately 25 µm to 85 µm.	1 coat epoxy primer:	50
		1 coat two component epoxy:  <u>1 coat topcoat:</u>	100  <u>75</u>
<b>Coating system no. 6B:</b> Hot dipped galvanised steel when painting is required.	Cleaning with alkaline detergent followed by hosing with fresh water.	Minimum DFT (µm) of complete coating system:	225
<b>Coating system no. 6C:</b> Insulated stainless steel piping and vessels at temperatures < 150 °C.	Sweep blasting with non-metallic and chloride free grit to obtain anchor profile of approximately 25 µm to 85 µm.	2 coats epoxy <u>phenolic</u> :	<u>2 x 125</u>
		Minimum DFT (µm) of complete coating system:	250
NOTE 1 Coatings for stainless steel shall not contain metallic zinc.			
NOTE 2 6Mo and 25Cr duplex stainless steel valves may be left uncoated. When such valves are welded into the piping system, the coating shall cover the weld zone and an additional 40 mm of the valve.			
NOTE 3 When coating stainless steel with maximum operating temperatures above 150 °C, a high temperature modified coating suitable for the operating temperatures shall be used.			
NOTE 4 Aluminium handrails located in living quarter shall be anodised.			
NOTE 5 Aluminium including handrails and ladders located outdoors in marine atmosphere shall only be painted if specifically required e.g. due to safety requirements			
NOTE 6 Hot dip galvanized steel may be coated with a 75 µm polyester powder coating. Surface preparation of the zinc prior to powder coating: Zinc manganese phosphate conversion coating.			
NOTE 7 Aluminium may be coated with a 75 µm polyester powder coating. Surface preparation of the aluminium prior to powder coating: Chromate conversion coating.			
NOTE 8 Only topcoats already pre-qualified in coating system no. 1 shall be used for coating system 6A and system no. 6B.			

**A.7 Coating system no. 7 (shall be pre-qualified)**

Application (if not specified under others)	Surface preparation	Coating system (example)	Minimum DFT $\mu\text{m}$
<b><u>Coating system no. 7A:</u></b> Carbon and stainless steel in the splash zone	Cleanliness: ISO 8501-1 Sa 2½ Roughness: ISO 8503 Grade Medium G (50 $\mu\text{m}$ to 85 $\mu\text{m}$ , R <sub>y5</sub> )	Two component epoxy or polyester based coating. Minimum number of coats: 2 Complete coating system:	600
<b><u>Coating system no. 7B:</u></b> Submerged carbon and stainless steel $\leq 50$ °C		Two component epoxy Minimum number of coats: 2 Complete coating system:	350
<b><u>Coating system no. 7C:</u></b> Submerged carbon and stainless steel $> 50$ °C		Two component epoxy Minimum number of coats: 2 Complete coating system:	350
NOTE 1	Stainless steel shall be blasted with non-metallic and chloride free abrasive.		
NOTE 2	The coating system shall always be used in combination with cathodic protection.		
NOTE 3	For the splash zone, corrosion allowance in accordance with applicable regulatory requirements shall always be used in addition to the coating system, see NORSOK M-001.		
NOTE 4	Anti-fouling may be required.		
NOTE 5	Piping embedded in concrete shall be corrosion coated at least 300 mm into concrete.		
NOTE 6	For the splash zone area, system no. 7A, the coating system shall also fulfil the pre-qualification requirements for coating system no. 1.		

**A.8 Coating system no. 8**

Application (if not specified under others)	Surface preparation	Coating system alternatives	DFT µm
Structural carbon steel with maximum operating temperature ≤ 80 °C in internal and fully dry and ventilated areas.	Cleanliness: ISO 8501-1 Sa 2½	A. 1 coat two component epoxy  B. Zinc rich epoxy + epoxy tie coat	150  60 + 25
<p>NOTE 1 This coating system shall only be used if the areas are only exposed to fully dry indoor conditions during fabrication, intermediate storage, installation and operation. The coating system shall not be used on surfaces where water condensation may occur.</p> <p>NOTE 2 Reduced requirements (maximum 50 mg/m<sup>2</sup>) to salt on surface prior to coating are acceptable.</p> <p>NOTE 3 Surface preparation to minimum St 2 may be used for touch-up.</p> <p>NOTE 4 Topcoat may be applied if specific colours are specified.</p> <p>NOTE 5 Equipment to be installed in non-corrosive areas as defined in the first note above (e.g. electrical rooms, control rooms, living quarters, etc.), may normally be coated with suppliers standard coating system and colour. All such coating systems shall be subject to written acceptance from the purchaser.</p>			

**A.9 Coating system no. 9**

Application (if not specified under others)	Surface preparation	Coating system	DFT µm
Bulk supplied carbon steel valves with maximum operating temperature up to 150 °C.	Cleanliness: ISO 8501-1 Sa 2½  Roughness: ISO 8503 Grade Medium G (50 µm to 85 µm, R <sub>v5</sub> )	2 coats epoxy phenolic:  Minimum DFT (µm) of complete coating system:	<u>2 x 150</u>  300
<p>NOTE 1 When it is possible to identify the operating conditions (e.g. temperature, insulation, exposure conditions, etc.) at the time the order is placed, the bulk ordered valves shall be supplied coated with one of the relevant coating systems in this NORSOK standard.</p> <p>NOTE 2 Tagged items shall always be supplied coated with one of the relevant coating systems in this NORSOK standard.</p> <p>NOTE 3 Alternative system, if agreed with purchaser may be: 1x75 µm Zinc ethyl silicate and an epoxy tie coat, in accordance with system no. 1. Final coating shall then be done after installation.</p>			

## **Annex B (Informative) Colours**

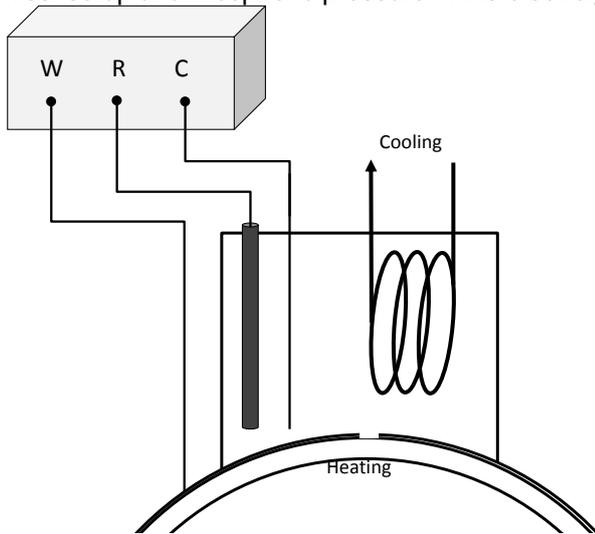
The below topcoat colours should be selected:

<b>Colour</b>	<b>RAL-1K designation</b>
White	RAL 9002 (Grauweiss)
Blue	RAL 5015 (Himmelblau)
Grey	RAL 7038 (Achalgrau)
Green	RAL 6002 (Laubgrün)
Red	RAL 3000 (Feuerrot)
Yellow	RAL 1004 (Goldgelb)
Orange	RAL 2004 (Reinorange)
Black	RAL 9017 (Verkehrsschwarz)

## Annex C (Informative) High temperature cathodic disbonding Test setup examples

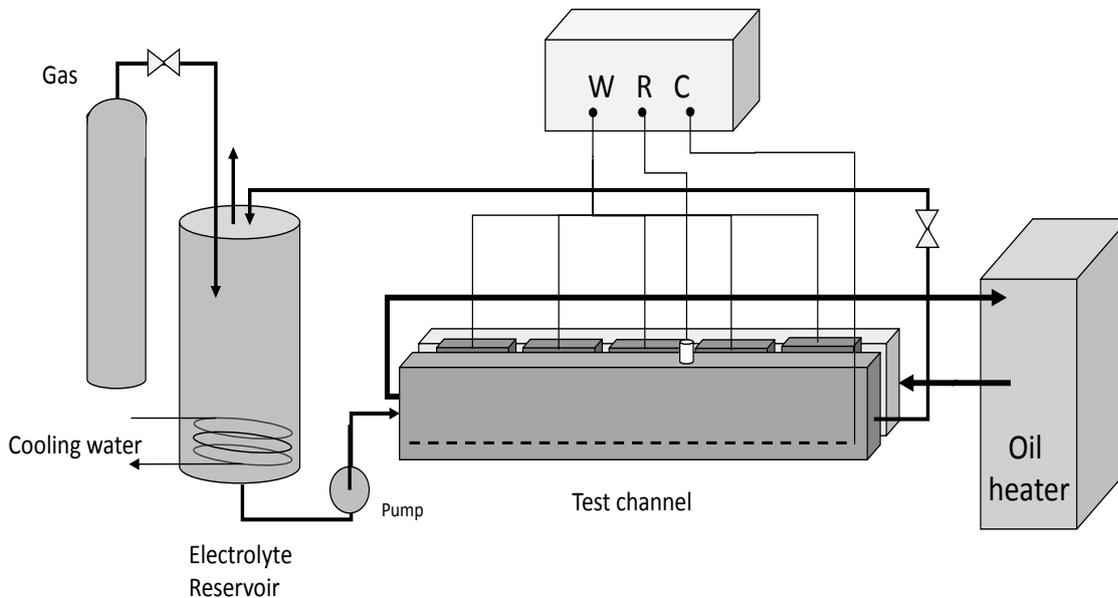
### Example 1<sup>1</sup>

Test setup at atmospheric pressure in the electrolyte (<100 °C steel temperature)



### Example 2<sup>2</sup>

Test setup with pressurized electrolyte and samples heated by flowing oil (>100 °C steel temperature).



<sup>1</sup> NF A 49-711. "External three-layer polypropylene-based coating". Appendix K

<sup>2</sup> Knudsen OØ, Brende KK, Gundersen H: "Cathodic Disbonding at High Temperature". Paper No. 11023, CORROSION 2011 (NACE, Houston TX)



**Inspection results pages**

<b>Paint cycle</b>			
First coat:	Nom. thickness, $\mu\text{m}$ :	Thinner:	
Second coat:	Nom. thickness, $\mu\text{m}$ :	Thinner:	
Third coat:	Nom. thickness, $\mu\text{m}$ :	Thinner:	
Fourth coat:	Nom. thickness, $\mu\text{m}$ :	Thinner:	
Comments:			
<b>Visual receive control</b>			
Date of receive control:		Steel preparation according ISO 8501-3	
Edges rounded:	Major surface defects:	Weld splatters, slivers:	All signs off:
Continually welds:	All welds dressed:	Bolts and nuts protected:	End caps on:
Rust grade:			
Comments:			
<b>Cleaning</b>			
Date of cleaning:		Oil, grease, corrosion inhibitors and salt removed:	
Method of cleaning:		Type of detergent:	
If machined surfaces; strength of detergent:		Cleaned with freshwater after use of detergent:	
Comments:			
<b>Abrasive blasting</b>			
Blasting machine:		Open blasting:	
Abrasive type:		Abrasive size:	
Start blasting, Date:	Time:	End blasting, Date:	Time:
Air temp, $^{\circ}\text{C}$ :	Surface temp., $^{\circ}\text{C}$ :	Humidity, %:	Dew point, $^{\circ}\text{C}$ :
Comments:			
<b>Surface cleanliness and roughness</b>			
<b>Requirements to cleanliness and roughness</b>			
Requirements to cleanliness:		Requirements to roughness:	
Type of material to be blasted:		Abrasive quality:	
<b>Tested cleanliness and roughness</b>			
Date of test of cleanliness and roughness:			
Test equipment for cleanliness:		Tested cleanliness:	
Test equipment for roughness:		Tested roughness:	
Comments:			
<b>Salt test</b>			
<b>Requirements to salt concentration</b>			
Requirements to max salt concentration: 20 mg/m <sup>2</sup> NaCl			
<b>Tested salt concentration</b>			
Date of test of salt concentration:			
Salt test equipment:		Tested salt concentration:	
Comments:			
<b>Visual inspection after blasting</b>			
Date of visual inspection:			
All parts blasted without holidays:		Rust grade:	Edges:
Weld splatters and pores in welds:		Major surface defects:	Pores/holes in casting:
Comments:			

Each coat			
Product name:		Colour, RAL Code:	
Batch no.:		Exp. date:	
Start application, date:	Time:	End application, date:	Time:
Application method:		Stripe coat applied:	
Max. thinner allowed, %:		Actual thinner added, %:	
Environmental control instrument:			Blotter test:
Air temp., °C:	Surface temp., °C:	Humidity, %:	Dew point, °C:
Comments:			
Paint thickness, each coat			
Requirement to thickness according to CSDS:			
Average DFT, µm:	Min. DFT, µm:	Max. DFT, µm:	
Measured thickness of each coat			
Date of test of paint thickness control:			
Film thickness control instrument:		No. of measures:	
Average DFT, µm:	Min. DFT, µm:	Max. DFT, µm:	
Visual inspection after coating			
Date of visual inspection:			
Contaminations:	Solvent retention:	Pinholes/popping:	
Sagging:	Wrinkling:	Surface defects:	
Comments:			
Adhesion			
Requirements to adhesion test			
Adhesion test according to:		ISO 4624	
Absolute minimum adhesion based on NORSOK M-501, MPa		Absolute minimum adhesion based on Coating Procedure Test (CPT), MPa	
Assumed temperature during curing, °C:		Calculated necessary curing time (h):	
Adhesion test results			
Date of gluing dollies to the test plate:		Date of pull-off:	Temp. during curing, °C:
Adhesion test instrument:		Film thickness on tested surface, µm:	
Is the test performed on the object or on a test plate?:			
If test plate, has the test plate been treated as the object?:			
Diameter of dolly, mm:	Expiry date of glue:	Type of glue:	
Adhesion value (MPa):	Failure description (% adhesive/ cohesive/glue):		
Comments:			
Verification of curing (i.e. MEK-test or curing of phenolic epoxy)			
Requirement to curing			
Measured film thickness, µm:		Allowed range of air humidity, % RH:	
Assumed temperature during curing, °C:		Calculated necessary curing time (h):	
Curing log			
Start curing, date:	Time:	End curing, date:	Time:
Mean temp. during curing, °C:		Actual curing time, hrs.:	
Measured air humidity, % RH:		Curing control method:	
Comments:			
Holiday test			
Requirement to holiday test			
Requirement to holiday test: No holidays			
Holiday test result			
Date of holiday test:		Test instrument:	
Result of holiday test:			
Comments:			

