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Petroleum, petrochemical and natural gas industries — Internal coating and lining of steel storage tanks

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National foreword

This British Standard is the UK implementation of EN ISO 16961:2015.

The UK participation in its preparation was entrusted to Technical Committee PSE/17, Materials and equipment for petroleum, petrochemical and natural gas industries.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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European foreword

This document (EN ISO 16961:2015) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2016, and conflicting national standards shall be withdrawn at the latest by February 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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Endorsement notice

The text of ISO 16961:2015 has been approved by CEN as EN ISO 16961:2015 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries.*

Introduction

This International Standard is based on GSO 2057 – 2010 (E). The objectives of this International Standard are to define minimum technical requirements for the corrosion protection by coating and lining of internal surfaces of steel storage tanks, to provide technical guidance for developing local standards and specifications, and to ensure compliance in coating and lining material selection and performance with contract requirements.

Users of this International Standard should be aware that further or differing requirements can be needed for individual applications. This International Standard is not limiting the contractor and/or manufacturer from proposing or the company from accepting alternative engineering solutions for the individual application. This can be particularly applicable where there is innovative or developing technology. Where an alternative is proposed, the specification issuer should identify any deviations from this International Standard and provide details.

Annexes A, B, C and D of this International Standard are informative only.

Petroleum, petrochemical and natural gas industries — Internal coating and lining of steel storage tanks

1 Scope

This International Standard specifies the minimum requirements for surface preparation, materials, application, inspection and testing of internal coating lining systems that are intended to be applied on internal surfaces of steel storage tanks of crude oil, hydrocarbons and water for corrosion protection.

It covers both new construction and maintenance works of tank internal coating and lining as well as the repair of defective and deteriorated systems.

This International Standard also provides the minimum requirements for shop performance testing of the coated/lined samples and the criteria for their approval.

2 Conformance

2.1 Rounding

Unless otherwise stated in this International Standard, to determine conformance with the specified requirements, observed or calculated values shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with ISO 80000-1:2009, Annex B, Rule A.

NOTE For the purpose of this provision, the rounding method of ASTM E29–08 is equivalent to ISO 80000-1:2009, Annex B, Rule A.

2.2 Compliance to this International Standard

A quality system should be applied to assist compliance with the requirements of this International Standard. ISO/TS 29001 gives sector-specific guidance on quality management systems.

The applicator shall comply with all of the applicable requirements of this International Standard. It shall be permissible for the client to make any investigations necessary in order to be ensured of compliance by the applicator and to reject any material that does not comply.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API RP 652, *Lining of Aboveground Petroleum Storage Tank Bottoms*

API STD 653, *Tank Inspection, Repair, Alteration and Reconstruction*

API STD 2015, *Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks*

ASTM C868-02 (2012), *Standard Test Method for Chemical Resistance of Protective Linings*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers — Tension*

ASTM D522, *Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings*

ASTM D610, *Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces*

ASTM D714, *Standard Test Method for Evaluating Degree of Blistering of Paints*

ASTM D790, *Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*

ASTM D870, *Standard Practice for Testing Water Resistance of Coatings Using Water Immersion*

ASTM D2583, *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*

ASTM D4060, *Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser*

ASTM D4285, *Standard Test Method for Indicating Oil or Water in Compressed Air*

ASTM D4541, *Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers*

ASTM D4940, *Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives*

ASTM D5420, *Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact)*

ASTM F21, *Standard Test Method for Hydrophobic Surface Films by the Atomizer Test*

ASTM G42, *Standard Test Method for Cathodic Disbonding of Pipeline Coatings Subjected to Elevated Temperatures*

EN 14020 (all parts), *Reinforcements — Specification for textile glass roving's*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 2812-1, *Paints and varnishes — Determination of resistance to liquids — Part 1: Immersion in liquids other than water*

ISO 3233 (all parts), *Paints and varnishes — Determination of percentage volume of non-volatile matter by measuring the density of a dried coating*

ISO 4624, *Paints and varnishes — Pull-off test*

ISO 4628-2, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering*

ISO 4628-3, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting*

ISO 7027, *Water quality — Determination of turbidity*

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*

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 — Tests 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 — Tests 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 -- Tests for the assessment of surface cleanliness -- Part 9: Field method for the conductometric determination of water-soluble salts*

ISO 10474, *Steel and steel products — Inspection documents*

ISO 11124 (all parts), *Preparation of steel substrates before application of paints and related products — Specifications for metallic blast-cleaning abrasives*

ISO 11126 (all parts), *Preparation of steel substrates before application of paints and related products — Specifications for non-metallic blast-cleaning abrasives*

ISO 11127-7, *Preparation of steel substrates before application of paints and related products — Test methods for non-metallic blast-cleaning abrasives — Part 7: Determination of water-soluble chlorides*

ISO 12944-3, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Part 3: Design considerations*

ISO 19840, *Paints and varnishes — Corrosion protection of steel structures by protective paint systems — Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces*

ISO 29601, *Paints and varnishes — Corrosion protection by protective paint systems — Assessment of porosity in a dry film*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

NACE SP0188, *Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates*

NACE/TM 0174, *Standard Test Method — Laboratory Methods for the Evaluation of Protective Coatings and Lining Materials on Metallic Substrates in Immersion Service*

SSPC-AB1, *Abrasive Specification No.1, Mineral and Slag Abrasive*

SSPC-AB2, *Abrasive Specification No.2, Cleanliness of Recycled Ferrous Metallic Abrasives*

SSPC-Guide 12, *Guide for Illumination of Industrial Painting Projects*

SSPC-PA 2, *Steel Structure Painting Council Surface Preparation Specifications Measurement of Dry Coating Thickness with Magnetic Gages*

SSPC-SP 1, *Steel Structure Painting Council Surface Preparation Specifications — Solvent Cleaning*

SSPC-SP 5/NACE No.1, *Joint Surface Preparation Standard-White Metal Blast* Cleaning

SSPC-SP 11, *Surface Preparation Standard, Power-Tool Cleaning to Bare Metal*

4 Terms, definitions and abbreviated terms

4.1 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

4.1.1
application procedure specification
APS
document describing procedures, methods, equipment and tools used for coating application

4.1.2
applicator
organization, contractor or subcontractor having the technical capability, knowledge, equipment and qualified personnel that is approved by the client for the coating processes as required by this International Standard

4.1.3
C glass
glass fibre that provides greater resistance to chemicals and is used in advanced composites, mainly used in the form of surface tissue in the outer layer of laminates used in chemical and water pipes and tanks

4.1.4
caulking
the process of applying a 98 % to 100 % solid catalysed epoxy material (caulking compound) on tank internal surfaces to fill pores/pits or to cover weld seams, lap joints, large projections, connections, etc.

Note 1 to entry: This is to provide a uniform gradual transition and smooth surfaces.

4.1.5
client
party or organization for which professional services are rendered or person that receives a product

4.1.6
coat
paint, varnish or lacquer applied to surface in a single application (one layer) to form an evenly distributed film when dry

4.1.7
contractor
vendor company or business that agrees to furnish materials and/or perform specific project/services to client

4.1.8
curing
chemical process of developing the intended properties of a coating/polymerized product in the lining system, generally due to a reaction between two or more chemicals (e.g. resin and curing compound)

4.1.9
dew point
temperature of a given air/water vapour mixture at which condensation starts, since, at that temperature, its maximum water content saturation is reached

4.1.10
dry abrasive blasting
surface preparation method that uses an abrasive propelled by air pressure, centrifugal force, to clean and provide a surface profile

4.1.11
dry film thickness
DFT
thickness of a coat or coating system in its fully cured and dry condition

Note 1 to entry: The dry film thickness of coating is measured by film thickness calibrated gauge and expressed in mils or microns (1 000 microns is equivalent to 40 mils).

4.1.12
E glass
glass containing not more than 1 % by mass of alkali (calculated as Na_2O) and used for the manufacture of glass fibre

4.1.13
epoxy
resin containing epoxide functional groups that allow for curing by polymerization with a variety of curing agents

4.1.14
fibreglass lining
cold curing resin linings to repair and/or add strength to tank bottoms with fibre mat

Note 1 to entry: Examples are pure epoxies, phenolic epoxies, polyesters, vinyl esters being chemically cured with curing agents.

4.1.15
fibreglass reinforced lining
resin linings, usually polyester, vinyl ester or epoxies, into which layers of fibreglass are incorporated to enhance the lining's structural capability, corrosion and chemical resistance performance

4.1.16
fibre mat
woven glass fibre that is used as reinforcement of the thermosetting resin (e.g. epoxy) lining to repair and/or add strength to tank bottoms

Note 1 to entry: Fibre mat is typically applied to a wet resin at about 450 g/m^2 area.

4.1.17
gel coat
final coat applied over the fibreglass lining laminate to seal the laminate surface and enhance water and hydrocarbon resistance

4.1.18
holiday
discontinuity in a lining (e.g. pinhole, void, crack, thin spot, and inclusion of foreign material) or contamination in the coating film that significantly lowers the dielectric strength of the coating

4.1.19
lining
material applied to the internal surfaces of a tank to serve as a barrier to corrosion and/or product contamination

Note 1 to entry: The term coating is also used for the purposes of this International Standard.

4.1.20
manufacturer
company responsible for the manufacture of coating material(s)

4.1.21
pinhole
small film defect characterized by small pore-like flaws in the lining that would permit corrosion of the substrate under the conditions for which the lining is designed

Note 1 to entry: A pinhole may extend entirely through the film to the substrate and lead to a holiday.

4.1.22
pre-production trial
PPT
application of coating and inspection/testing of its properties, to confirm that the APS is able to produce a coating with the specified properties

4.1.23
surface profile
micro-roughness of a surface, generally expressed as the average height of the major peaks relative to the major valleys, sometimes referred to as amplitude

Note 1 to entry: It is typically Ra/Ry/Rz value.

4.2 Abbreviated terms

ANSI	American National Standardization Institute
API	American Petroleum Institute
APS	Application Procedure Specification
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BGAS	British Gas
CV	Curriculum Vitae
DFT	Dry Film Thickness
GRE	Glass Reinforced Epoxy
GRUP	Glass Reinforced Unsaturated Polyester
GRVE	Glass Reinforced Vinyl Ester
GSO	Gulf Standardization Organization
HBE	High Build Epoxy
HSE	Health, Safety and Environment
ITP	Inspection and Testing Plan
MSDS	Materials Safety Data Sheets
NACE	National Association of Corrosion Engineers
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
PPT	Pre-Production Trial
PQT	Procedure Qualification Trial
QA/QC	Quality Assurance/Quality Control
QP	Qualification Procedure
RH	Relative Humidity
RP	Recommended Practice
SOW	Scope of Work
SSPC	The Society for Protecting Coatings
WFT	Wet Film Thickness
WRAS	Water Regulations Advisory Scheme

5 Pre-work requirements

5.1 General

5.1.1 All necessary health, safety and environmental (HSE) procedures shall be employed to protect personnel and the surrounding environment during on-site/field works.

5.1.2 The contractor shall submit their HSE manual for client approval. The approved HSE procedures for the safe lining processes shall be strictly followed.

5.1.3 Adherence to all relevant international safety requirements, client safety regulations for contractors and lifting equipment regulations are required while performing coating and lining works.

5.1.4 Materials Safety Data Sheets (MSDS) for all chemicals to be used within operation areas shall be submitted for review and approval by client. Health and safety precautions shall be clearly described on each chemical container/package.

5.1.5 All wastes resulting from supply and application shall be contained, collected and properly disposed off in accordance with international/local environmental protection standards/regulations.

5.2 Safety precautions in flammable atmosphere

5.2.1 Where there is a risk of flammable atmosphere being present in a particular tank, the client may, with relevant safety authority, impose restrictions on methods of surface preparation.

5.2.2 The client shall advise on the hazardous area classification for plant design and construction/ maintenance projects.

5.2.3 The contractor shall provide the client with all necessary data for the proposed coating/lining systems, solvents and coating procedure in order to permit area classification to be determined for the duration of coating work. Special care shall be observed when mixing resins to avoid fire hazards.

5.2.4 All equipment used in surface preparation, coating/lining application and inspection, including floodlight or spotlights, shall be explosion-proof and spark-proof.

5.3 Safety precautions in confined space

The procedures for performing safe work in confined spaces shall be in accordance with OSHA 29 CFR 1910, API STD 2217A or according to national legislation.

5.4 Qualification of coating/lining application and inspection personnel

5.4.1 The coating/lining operatives shall be competent to undertake the coating application, inspection/ testing procedures and repair work. The qualification may be obtained as agreed with the client or by demonstration at a procedure qualification trial (PQT) during pre-production trial (PPT).

5.4.2 Inspectors and applicator personnel carrying out the coating inspection shall be competent to carry out the requirements of this International Standard. The applicator shall request the manufacturer of the coating/lining material(s) and equipment to provide technical assistance to the coating/lining operatives if necessary.

5.5 Positive isolation and ventilation

5.5.1 All pipeline/piping shall be disconnected at the tank valves and the open ends of pipes shall be blanked off. All tubular housing and conduits connected to the tanks for gauging or other instrumentation purpose shall be disconnected. Cathodic protection system shall be disconnected only during the actual surface preparation and coating application works. The tank shall have provision to exhaust gases from the tank by at least two air changes per hour and vented at high level on the downwind side. The exhaust and ventilation shall comply with local and national HSE regulations.

5.5.2 The tank shall be lighted in accordance with SSPC-Guide 12 and shall be ventilated. Any client-related standards shall take precedence. All parts of the work shall be clearly visible.

6 Coating/lining materials

6.1 General

6.1.1 Typical coating and lining systems include high build solvent free glass-flake filled coating, hand lay fibreglass reinforced lining (GRE, GRVE, GRUP), solvent free epoxy, phenolic epoxy, epoxy novolac and high build epoxies.

6.1.2 All coating/lining materials shall be free of foreign elements and contaminants. The age of materials components shall not exceed the recommended shelf-life as limited by the manufacturers.

6.1.3 The coating/lining materials shall be delivered to the site in original manufacturer's sealed un-opened containers with batch number, date of manufacture and expiry date clearly marked thereon.

6.1.4 All coating/lining materials intended to be used shall have five years' proven performance in the relevant service liquid. The details shall be submitted to the client for review and approval.

6.1.5 The coating and lining systems to be used and the areas to be lined for each tank shall be specified by the client project specification and equipment data sheet.

6.1.6 The coating work shall be undertaken by applicators, including supervisors and workers, with experience on installing the type of internal coating/lining specified as per the manufacturer instructions and client requirements.

6.2 Approvals

6.2.1 All coating/lining materials and thinners in any (multi-coat) system shall be manufactured by a single manufacturer to avoid any compatibility issues. For a particular project or maintenance job, the use of different materials shall be subject to the client's and paints manufacturers' written approval.

6.2.2 The contractor's submittal for coating/lining materials shall include details of the manufacturer, technical specifications and performance testing of the materials to be used for the client's review and approval.

6.2.3 Manufacturer's certificates shall be furnished with all coating/lining materials and shall confirm that the material complies with the requirements of this International Standard.

6.2.4 The selected coating/lining materials, provided by the contractor, shall comply with 6.3 to 6.13 or as mentioned in relevant technical specification/datasheets.

6.2.5 For potable water service the lining shall possess certificate of clearance to store water for human consumption from the local water regulating authority or should comply with ANSI/AWWA/WRAS standards for interior of potable water storage tanks with the appropriate temperature rating.

6.3 Procedure qualification trial (PQT)

6.3.1 If specified by the client or otherwise required by this International Standard, the application procedure specification (APS) shall be qualified by a PQT. Test methods and frequencies for PQT are specified in 6.5 to 6.13. Acceptance criteria are given in the relevant subclauses referred to in 6.5 to 6.13.

6.3.2 The applicator may request the manufacturer(s) to assist during the PQT to ensure the correct use of the coating/lining material(s) and to train applicator personnel.

6.3.3 Qualification tests shall be carried out on representative test plates having the same specification and thickness as the storage tank to be internally coated/lined.

6.3.4 All tools and equipment (e.g. for abrasive blasting, coating/lining application and inspection) being used for PQT shall be of the same type as those being used for the actual coating/lining.

6.3.5 The method of coating repairs and stripping of defective internal tank coating/lining shall be included in PQT.

6.3.6 The applicator shall submit a complete report of the qualification test results to the client or his representative for approval.

6.4 Pre-production trial (PPT)

6.4.1 If specified or otherwise required by the client, a PPT shall be performed on site to verify the:

— coating/lining system;

— coating/lining materials;

— coating/lining application procedure;

— qualification of equipment being used for surface preparation and coating application;

— application of the coating system;

— qualification of the coating operatives and inspectors that will actually be used in the field.

6.4.2 The PPT work and performance shall comply with the requirements of this International Standard and the results of any previous PQT.

6.4.3 Test methods, frequencies and acceptance criteria for PPT are identified and specified in the relevant subclauses of 6.5 to 6.13.

6.4.4 The PPT shall be carried out in the presence of the client and/or applicator (or their representative) at the start of operations when equipment and personnel are mobilized on site. The PPT shall be performed on the first test plate to be coated.

6.5 Holding (blast) primer

An approved rapid curing primer can be used as holding primer. Holding primer shall be spray applied. Holding primer can be applied by brush on small surfaces in case of minor repair. The approved holding primer shall be compatible with the lining system and as specified in the lining system material datasheet.

6.6 Caulking (putty) and filler compounds

6.6.1 Caulking (putty) compound shall be a mixture of solvent-free resin and aggregates. The caulking shall provide great strength and chemical resistance and shall be compatible with the lining system.

6.6.2 Filler compound shall be 100 % volume solids and compatible with the lining system.

6.6.3 The approved putties and fillers shall be as specified in the lining system material data sheet.

6.6.4 Surface preparation for better anchoring and maximum thickness of caulking (putty) and sealer compounds to be applied shall be mentioned considering corrosion allowance of metal substrate and operating conditions (loading /unloading vibrations) of tank in scope.

6.7 Fibreglass lining materials

6.7.1 Fibreglass resin compound

The resin compound for the fibreglass lining system shall be chemical and corrosion resistance type, which include bisphenol epoxy resin, epoxy phenolic or novolac epoxy, polyester and vinyl ester. The resin shall be of high quality in order to meet the performance requirements as mentioned in this International Standard. The epoxy resin should be type 1 Grade 1 as per ISO 3673-1 or ASTM D1763. The bisphenol epychlorohydrin epoxide resin shall be 100 % pure of low viscosity at normal room temperature. Epoxy resin may be an amine adduct cured. Epoxy base blends shall be high molecular weight, resins of low viscosity at normal room temperature. Also, it shall be as per material manufacturer recommendation for specified storage services with coverage of proven performance assurance.

6.7.2 Glass fibre reinforcement

6.7.2.1 Glass fibre reinforcement shall be type E or C glass fibre roving as per EN 14020 of size 0,4 mm in diameter of low alkali borosilicate glass, evenly distributed in a random pattern and bound together with a chemical binder highly soluble in the laminating resin. Also, it shall be as per material manufacturer recommendation for specified storage services with coverage of proven performance assurance.

6.7.2.2 For laminated fibreglass reinforced lining (hand applied), the mat shall have a minimum weight of 300 g/m^2, a minimum width of 1 250 mm and shall contain a high solubility binder. The fibreglass mat shall be of suitable lengths. The overlap between the fibreglass mats should be minimum 100 mm along the length of the mat.

6.7.2.3 The glass surface tissue (surface veil) shall be a light weight glass fibre with a minimum weight of 300 g/m^2, if required.

6.7.2.4 Top coat shall be applied over the fibreglass lining laminate to seal the laminate surface and enhance water and hydrocarbon resistance. This top coat is also referred to as gel coat, seal coat or flood coat.

6.7.2.5 Glass reinforced schemes, where the fibre is incorporated via methods other than hand applied (e.g. chopped glass schemes), shall be allowed provided they can be shown to comply with the performance requirements of this International Standard.

6.8 Glass flake filled coating/lining system

6.8.1 The resin compound for glass flake filled coating/lining system shall be as specified in 6.7.1

6.8.2 The other resin materials are bisphenol A/novolac vinyl ester and isopthalic/bisphenol A/chlorinated unsaturated polyester.

6.8.3 The glass flake shall be borosilicate, C glass fibre platelets with excellent water/chemical resistance. The size of the flake shall be in the range 2 µm to 7 µm thick and 600 µm to 4 000 µm wide. The C glass shall be as per EN 14020.

6.8.4 The chemical resistance information shall state whether the material has been laboratory tested, e.g. according to ISO 2812-1, Method B, or other equivalent standard.

6.9 Epoxy coating/lining systems

6.9.1 The phenolic epoxy shall be amine cured and shall be capable to withstand a service temperature (immersed in service liquid as specified in the scope of this International Standard). Also, it shall be as per material manufacturer recommendation for specified storage services with coverage of performance guarantee.

6.9.2 The high build epoxy (HBE) shall be amine cured. The volume solids shall be minimum 70 %. HBE shall be capable to build up the recommended thickness in a single or maximum two coats without any film defects.

6.9.3 Solvent free epoxy shall be high build and suitable for using in storage items for which they are intended. For potable water service the lining shall possess certificate of clearance to store water for human consumption from the local water regulating authority or should comply with ANSI/AWWA/WRAS standards for interior of potable water storage tanks.

6.10 Thixotropic agent for viscosity control

To prevent sagging or dripping on vertical surfaces, a thixotropic agent which has nil or negligible effect on the properties of the cured resin system and the ease of application may be used.

6.11 Material approvals — Fibreglass lining system

6.11.1 Original certificates from a testing laboratory, operating in compliance with ISO/IEC 17025, shall be submitted to the client to prove that the fibreglass lining meets the minimum specifications presented in Table 1.

Table 1 — Minimum specifications fibreglass lining

Properties	Test method	Minimum specification
Adhesion (after immersing the lining into 60 °C water for 24 h)	ISO 4624	10 MPa (A/B failure)
Cathodic disbondment	ASTM G42 at 60 °C	15 mm max.
Solids content	ISO 3233	100 % ±2 %
Total DFT of the system	ISO 19840	As per manufacturer
Impact resistance	ASTM D5420 (2 J (40 in-lbs))	No holiday
Chemical resistance	ISO 2812-1, Method B ASTM C868–02 (2012)	As per coating manufacturer and client agreement
Flexibility test	ASTM D790	As per coating manufacturer and client agreement
Hardness, Barcol	ASTM D2583	As per coating manufacturer and client agreement
Abrasion resistance	ASTM D4060 (1 000 cycles, CS17 wheel)	As per coating manufacturer and client agreement
Water absorption	ASTM D870	As per coating manufacturer and client agreement
Elongation	ASTM D412	As per coating Manufacturer and client agreement

6.11.2 The thickness shall be considered depending upon the service requirements, expected design life and per the coating/lining materials manufacturer's recommendations.

6.11.3 The quality of applied coating/lining work is subjected to client's approval upon quality inspection and surveillance, stage wise inspection and approval, reports and documentations with daily sign-off and then final inspection before box-up or handover of facility to client. The contractor shall submit a painted sample panel for client's shop for testing and analysis.

6.11.4 For all new products, the manufacturer and applicator shall prepare qualification test samples and production test samples. Fully cured samples shall be subjected to performance tests as per requirement of this International Standard as well as to the satisfaction of the client.

6.11.5 Sample panel specifications: the panel, to which the coating and lining system is applied, shall be a steel panel measuring 900 mm × 900 mm × 6 mm on which a vertical panel shall be welded at one side of height 300 mm. The panel shall be previously grit blasted and primed, in accordance to the technical specification of the lining system to be tested. DFT of primer coating shall be less than 25 µm. Within a 150 mm square in one corner on the side which is not primed shall clearly be printed or marked the name of the contractor and the date the sample is delivered to the client.

6.11.6 Fibreglass lining shop application: the lining and caulking shall be applied as per this International Standard. The mat overlap shall be at the minimum 100 mm and should be made at the middle of the test panel.

6.11.7 Sample plate testing procedures are as specified in 6.11.7.1 to 6.11.7.4.

6.11.7.1 Upon completion of the complete lining system and the specified curing time, the sample is subjected to the tests described in 6.11.7.2 and 6.11.7.3.

6.11.7.2 Non destructive testing

— Visual inspection:

The sample panel shall be thoroughly inspected visually for general conditions of the surface finish, scattered pockets among fibreglass cross section, shrinkage, pinholes, cracks etc.

— Thickness measurements:

The dry film thickness (DFT) shall be checked according to ISO 2808 or SSPC-PA 2 on the panel using micrometer and another random four readings shall be measured by suitable thickness gauge. The DFT readings shall be recorded in the test report.

— Holiday detection test:

Pinhole detection test of the lining shall be carried out by suitable high voltage holiday (spark) testing instrument at a set voltage as recommended by ISO 29601, NACE SP0188 or manufacturers recommendations.

6.11.7.3 Destructive testing

— Adhesion test:

Adhesion test shall be carried out as per ISO 4624 or ASTM D4541 after immersing the sample panel in water (60 °C) for 24 h.

— Hardness test:

The hardness of the applied lining shall be checked at 10 different locations using a barcol hardness tester in accordance with ASTM D 2583. The minimum, maximum and average readings shall be recorded in the test record.

— Specimen preparation:

Upon completion of the non-destructive testing of 6.11.7.2, the panel should be machined cut by the contractor for destructive testing. A total of 8 test samples shall be machine cut, each of 50 mm × 400 mm dimension. Four (4) samples. shall be cut parallel to one edge and the other four (4) samples shall be perpendicular to this edge.

— Test procedure as per ASTM D522:

Two samples of each group shall be subjected to bending test as follows:

— Two (2) samples shall be placed on the machine bending guides with lining upward. The plunger of 100 mm width and 50 mm thickness shall be compressed in the middle of the sample supported on a span of 350 mm until it is lowered 50 mm from the top line of the guides. The condition of lining shall be checked for any cracks or splitting from the steel panel.

— Two (2) samples shall be placed on the machine bending guides with lining downward. The plunger of 100 mm width and 50 mm thickness shall be compressed in the middle of the sample supported on a span of 350 mm until it is lowered 25 mm from the top line of the guides. The condition of lining shall be checked for any cracks or splitting from the steel panel.

6.11.7.4 Acceptable limits

6.11.7.4.1 The results of the tests explained in 6.11.7.2 and 6.11.7.3 should clearly show the following acceptable limits:

— A good quality smooth surface finishes without any evidence of shrinkage or air pockets or any other defects among fibreglass cross section.

— The minimum lining DFT of the final coat shall be as specified in the lining systems requirements in Table 1.

— The lined sample panel shall be free from any pinholes, voids or other defects.

— The hardness should be as recommended by the lining manufacturer.

— All test coupons for bending tests shall be free of any surface cracks or splitting (separation) from the steel base.

— The caulking shall be free of any cracks and voids.

— The minimum adhesion value shall not be less than 10 MPa.

6.11.7.4.2 In order to consider that a sample has achieved the required specifications, the test results should comply with all limits mentioned in 6.11.7.4.1.

6.12 Material approvals — Glass flake filled coating/lining system

6.12.1 Original certificates from a testing laboratory, operating in compliance with ISO/IEC 17025, shall be submitted to the client to prove that the glass flake lining meets the minimum specifications presented in Table 2.

Table 2 — Minimum specifications glass flake filled coating/lining

Properties	Test method	Minimum specification
Adhesion (after immersing the lining into 60 °C water for 24 h)	ISO 4624	10 MPa (A/B failure)
Cathodic disbondment	ASTM G42 at 60° C	15 mm max.
Solids content	ISO 3233	100 %
Total DFT of the system	ISO 19840	As per manufacturer and client agreement and Table 4 and 5
Impact resistance	ASTM D5420 (2 J (40 in-lbs))	No holiday
Chemical resistance	ISO 2812-1, Method B ASTM C868–02 (2012)	As per coating manufacturer and client agreement
Flexibility test	ASTM D790	As per coating manufacturer and client agreement
Hardness, barcol	ASTM D2583	As per coating manufacturer and client agreement
Abrasion resistance	ASTM D4060 (1 000 cycles, CS17 wheel)	As per coating manufacturer and client agreement
Water absorption	ASTM D870	As per coating manufacturer and client agreement
Elongation	ASTM D412	As per coating Manufacturer and client agreement
Atlas cell testing (Parameters will be as per service conditions)	NACE/TM 0174, Method A (6 months)	ISO 4628-2 or ASTM D714 (no blisters) ISO 4628-3 or ASTM D610 (9 or better)

6.12.2 The quality of coating/lining work is subjected to the client's approval. The contractor shall submit a coated sample panel to the client's shop for testing and analysis.

6.12.3 For all new products, the manufacturer and applicator shall prepare qualification test samples and production test samples. Fully cured test samples shall be subjected to performance tests as per the requirements of this International Standard as well as to the client's satisfaction as detailed and applicable in 6.11.7.

6.13 Material approvals — Thin film epoxy coating/lining systems

6.13.1 Original certificates from a testing laboratory, operating in compliance with ISO/IEC 17025, shall be submitted to the client, to prove that the lining meets the minimum specifications as presented in Table 3.

Table 3 — Thin film epoxy coating/lining systems

Properties	Test method	Minimum specification
Adhesion (after immersing the lining into 60 °C water for 24 h)	ISO 4624	10 MPa (1 450 psi (A/B failure))
Cathodic disbondment	ASTM G42 at 60 °C	15 mm max.
Solids content	ISO 3233	70 %
Total DFT of the system	ISO 19840	As per manufacturer and client agreement and Table 4 and 5
Impact resistance	ASTM D5420 (2 J (40 in-lbs))	No holiday
Chemical resistance	ISO 2812-1, Method B ASTM C868–02 (2012)	As per coating manufacturer and client agreement
Flexibility test	ASTM D790	As per coating manufacturer and client agreement
Hardness, barcol	ASTM D2583	As per coating manufacturer and client agreement
Abrasion resistance	ASTM D4060 (1000 cycles, CS17 wheel)	As per coating manufacturer and client agreement
Water absorption	ASTM D870	As per coating manufacturer and client agreement
Elongation	ASTM D412	As per coating Manufacturer and client agreement
Atlas cell testing (Parameters will be as per service conditions)	NACE/TM 0174, Method A (6 months)	ISO 4628-2 or ASTM D714 (no blisters) ISO 4628-3 or ASTM D610 (9 or better)

6.13.2 The quality of applied coating/lining work is subjected to client's approval upon quality inspection and surveillance, stage wise inspection and approval, reports and documentation with daily sign-off and then final inspection before box-up or handover of facility.

6.13.3 For all new products, the manufacturer and applicator shall prepare qualification test samples and production test samples. Fully cured test samples shall be subjected to performance tests as per the requirements of this International Standard as well as to the client's satisfaction, as detailed and applicable in 6.11.7.

7 Surface preparation

7.1 General

7.1.1 Design, fabrication and surface finish requirements for steel tanks to be lined shall be in accordance with ISO 12944-3 and ISO 8501-3, unless otherwise specified by the client's specification. Repair of tank bottom (maintenance work) shall be in accordance with API RP 652 and API STD 653.

7.1.2 The surfaces to be coated or lined shall be prepared and cleaned by the coating applicator in accordance with the requirements of 7.2, 7.3, 7.4 and 7.5 before any lining work begins. If this work specified is not be done by the contractor, a third party independent inspector or personnel of the contractor, only if approved by the client, shall test to ensure that the surface meets the requirements of 8.4 and 8.5 before the lining work begins.

7.2 Tank pre-cleaning and residue removal (for rehabilitation work)

7.2.1 The tank shall be de-sludged and thoroughly cleaned to remove scale, salt, dirt, existing/temporary protective paint, and chalk and oil residues. The cleaning shall be in accordance with API STD 2015. Degreasing shall be carried out using vapour degreasing equipment or appropriate solvent in accordance with SSPC-SP 1. Degreasing detergent shall be of an emulsifying type. Cleaning is usually followed by a fresh water rinse to ensure complete removal of cleaning chemicals.

7.2.2 Roof legs and supports shall be lifted to drain oil accumulations. Legs and supports shall be jacked up off the bottom during lining application, and open ends shall be covered with plastic bags or any other acceptable method to prevent drip page on blasted or primed surfaces.

7.2.3 Plastic bags, for covering larger areas plastic tarpaulins, or any other acceptable method shall be used to protect against overhead drip page from counter weights, supports, etc.

7.3 Preparatory patching and grinding (for new and rehabilitation work)

7.3.1 Isolated corroded areas below minimum thickness shall be repaired/replaced as per the client's requirements, and contractor's recommendations.

7.3.2 All welds shall be continuous. No skip welding is permitted. All existing skip welds shall be upgraded to continuous welds.

7.3.3 The weld integrity between shell and angular or sketch plates shall be checked for welding defects.

7.3.4 Surface irregularities, such as weld spatter, sharp protrusions, slivers and porosity, shall be removed completely (made flush or ground smooth) as per ISO 8501-3, preparation grade P3. All sharp outside corners and edges shall be treated as per ISO 8501-3, preparation grade P3. Any other observed defects in welds and base metal should be referred to client for disposition.

7.3.5 Prior final surface preparations, the steel substrate shall be tested for chloride contamination, according to ISO 8502-6 and ISO 8502-9, or SSPC Guide 15, or client-approved standards and test equipment. Fresh water (conductivity reading of maximum 100 μS/cm) washing at minimum pressure of 210 bar (3 045 psi) is highly recommended prior to take-up any coating work including sweep blasting operation. A chemical additive with demonstrated capability to remove salts can be used in the water wash if agreed by the client.

7.3.6 Those surfaces that are, or are likely to be contaminated with oil or grease, shall be solvent cleaned with a suitable water-soluble biodegradable solvent using rags (for small areas), an immersion tank (for small items) or a spray gun (for large areas), in accordance with SSPC-SP 1. The solvent-cleaned surfaces shall then be thoroughly washed down with fresh water ensuring that the oil-water emulsion formed is completely removed from the metal.

7.3.7 Degreased and water washed surfaces shall be checked for residual oil and grease using the atomized water spray test as per ASTM F21 and further degreasing shall be carried out if residual oil or grease is found to be present. A black light test shall be used to check for oil contamination. Zero oil and grease contamination is the acceptable limit.

7.3.8 Washing with fresh water containing a suitable degreasing agent and even suitable approved solvent washing of partially painted components shall take place between coats, if surface is found to be contaminated.

7.4 Dry abrasive blasting cleaning

7.4.1 Prior to the start of blasting, the contractor shall select an appropriate abrasive type and mesh size to attain the specified surface profile. Only approved garnet or grit type abrasives shall be used. Sand or silica based abrasives shall not be used, other abrasive material for blast cleaning shall be used in line with local environmental regulations. The abrasive shall be used in accordance to the manufacturer's specifications, shall contain no impurities and shall be according to ISO 11124, ISO 11126 and ISO 11127-7, or other test method accepted by the client. For environmental reasons, only garnet abrasive shall be used for offshore blast cleaning. Neither sand nor contaminated recycled abrasive is allowed under any circumstances for blast cleaning.

7.4.2 The contractor may be asked to demonstrate to the client satisfaction that the selected abrasive will provide the specified surface profile and visual standard. This shall be done by blasting a representative piece of steel, then measuring the surface profile using replica tape as per ISO 8503-5 or NACE RP0287 or as per ASTM D4417 and comparing the surface finish to the appropriate visual standard, when viewed without magnification, the blasted surface shall conform to the appropriate visual standard.

7.4.3 The metal substrate shall be abrasive blast cleaned to the required visual standard on all types of steel immediately prior to coating in accordance with ISO 8501-1. Very thorough blast cleaning, near white metal finish (Sa $2\frac{1}{2}$), shall be used for maintenance works and white metal finish (Sa 3) shall be used for new steel. The surface profile height shall be as specified in 7.4.9, 7.4.10 and 7.4.11.

7.4.4 Blast cleaning combined with vacuum collection at the nozzle can be used to reduce atmosphere contamination within the tank.

7.4.5 The compressed air used in any cleaning method shall be free of water and oil. Adequate after cooler shall be fitted with suitable traps, separators and filters, which shall be regularly emptied of water and oil. Any accumulated moisture and oil in the air receiver vessel shall be removed by regular air purging. The air compressor shall under no circumstances operate at temperatures in excess of 110 °C. The air supply shall be checked for water and oil contamination as per the procedure specified in ASTM D4285 prior to blast cleaning and regularly throughout blast cleaning operations. The air supply shall be tested daily for cleanliness using a white cloth or white blotting paper test as per 9.4.1. The compressed air supply used for dry blast cleaning shall be of sufficient pressure and flow rate to enable rapid and efficient cleaning rates to be achieved. Blast cleaning shall be carried out at a minimum air pressure of 7 bar (101 psi). Air pressure close to the nozzle may be measured using a hypodermic needle on a manometer inserted into the rubber blast hose close to the nozzle.

7.4.6 All surfaces to be lined shall be cleaned to remove any dust, sand and debris etc. by using industrial vacuum cleaner/grit recovery unit just prior to lining application. The surfaces shall be tested for the presence of residual particulate matter as per the procedure specified in ISO 8502-3. The maximum acceptable size and quantity of retained matter shall be Class 2 Rating 2. All reasonable steps should be taken to keep the metal surfaces dry and to prevent contamination or damage of the blast cleaned surface as they are subject to client approval prior to priming.

7.4.7 Blast cleaned surfaces shall be coated certainly within at most four hours of cessation blast cleaning and before any visible rusting, discoloration, or other surface contamination occurs. In case of any flash rust found on the surface, the same shall be removed by light sweep blasting. The work shall be planned to ensure that this requirement is always met. The dehumidification equipment is recommended to avoid any flash rust formation. However, the first coat application shall always be performed with 4 h of the blast cleaning. Blasting shall be accomplished so that previously coated surfaces are not contaminated by abrasive or rust.

7.4.8 The weather conditions shall be monitored prior to and constantly throughout the work period. No dry blast cleaning operation and coating work shall be carried out when the temperature of the surfaces is less than 3 °C above dew point or the relative humidity of the air is greater than 85 % or the air or substrate temperature is below 5 °C.

7.4.9 For fibreglass lining, the surface profile shall be 75 µm to 100 µm.

7.4.10 For glass flake filled coating/lining, the surface profile shall be 75 µm to 100 µm.

7.4.11 For phenolic epoxy/high build epoxy/solvent free epoxy/solvent free elastomeric polyurethane systems, the surface profile shall be in the range 50 µm to 100 µm or as specified by the lining manufacturer.

7.5 Humidity control

7.5.1 Appropriately sized dehumidification equipment may be installed and operated from the beginning of abrasive blasting operation and kept in continual operation until the final coat of the tank lining has passed the barcol hardness reading or full curing as required by the lining manufacturer.

7.5.2 In the event of a breakdown or interruption of the dehumidification equipment that results in the relative humidity rising above 50 %, any surface area that exhibits flash rusting shall be re-blasted to achieve the required condition of ISO 8501-1 Sa 3, SSPC-SP 5/NACE No.1.

7.6 After blast cleaning

7.6.1 Following completion of abrasive blasting, the surface shall be brushed with a clean hair bristle or fibre brush, blown with compressed dry air and then vacuumed. The dust embedded on the cleaned surface shall be tested as per 9.5.5.

7.6.2 Any surface laps, scabs, or seams exposed by abrasive blasting shall be reported immediately to the client so as to take appropriate action.

7.6.3 The blast-cleaned surface shall be checked for the presence of soluble chlorides and other salts as per 9.5.4.

7.6.4 A surface holding primer or surface inhibiting treatment shall be applied in order to hold the blasted surface for a short period till the blasting and cleaning is completed unless dehumidification equipment is operated with a relative humidity less than 50 % during the entire surface preparation operation. Only a primers and inhibiting washes approved by the coating manufacturer of the tank coating/lining material can be used based on the project needs.

7.6.5 All personnel entering the tank after abrasive blasting shall wear rubber soled shoes with clean, disposable shoe covers, sweatbands and lint free gloves.

7.6.6 No acid washes or other cleaning solutions or solvents, including inhibitive washes intended to prevent rusting, shall be used on metal surfaces after being blasted. Proven and demonstrated environmental friendly acidic washes and coating compatible flash rust passivation washes may be used if agreed by the client and coating manufacturer.

7.6.7 A minimum of 100 mm (4 inches) around the edges of blasted areas shall be left un-primed if the entire surface to be coated cannot be blasted and primed on the same day. Subsequent blasting shall continue at a minimum of 25 mm (1 inch) into the primed surfaces. The rough edge shall then be feather edged by power tool or hand sanding with heavy grit wheel or sandpaper. The surface to be coated shall be free of loose and/or burnt coating.

7.7 Removal of existing laminate linings prior to abrasive blasting

7.7.1 The use of induction coil heating machines to destroy the bond of the existing laminate lining followed by lifting and removing segments of the laminate during maintenance lining/re-lining work may be approved in lieu of removal by abrasive blasting, subject to client approval.

7.7.2 Contractors wishing to use induction coil heating machines to remove old laminate linings shall provide complete information on the equipment and the methods of removal to client as part of their submittals for approval prior to commencing the work.

7.7.3 Abrasive blasting shall be conducted after all the laminate is removed and shall meet the requirements of 7.4, 7.5 and 7.6.

7.8 Striker plates, steel legs, risers, down comers and supports

7.8.1 When required striker plates shall be placed directly under each gauge hatch.

7.8.2 The striker plates shall be lined on both sides.

7.8.3 The lined striker plates shall be fixed over fibreglass lined reinforcing pad using epoxy resin that is compatible with lining materials.

7.8.4 Roof support legs, risers, down comers, filling lines, roof drain lines, steel supports, etc., shall receive coating of 100 % solids epoxy at a minimum of total DFT 750 µm (30 mils) or as specified in 8.7.2, up to a height as specified by the project specifications/data sheet.

7.8.5 All the reinforcement pads (even where the striker plates are kept above) shall have a full lining system.

7.8.6 The roof support legs shall be jacked up and supported to apply the full lining system on reinforcement pads. Temporary supports shall be designed in such a way that it will not damage the roof plates. Only alternate legs shall be lifted.

7.9 Safety precautions

7.9.1 The abrasive blast nozzle shall be bonded (grounded) to the work metal in order to prevent the build-up of electrostatic charges which could cause a spark discharge.

7.9.2 The blast operators shall wear appropriate clothing and safety equipment. The blasting hoods shall be connected to a source of clean air (as per client requirements). All other persons exposed to the blast dust and chemical fumes shall wear air supplied respirators.

7.9.3 Adequate lighting in accordance to SSPC-Guide 12 shall be used to provide good visibility during surface preparation works.

8 Coating/lining application

8.1 General requirements

8.1.1 Coating/lining works shall be in accordance with the requirements established by this International Standard and the recommendations of the coating manufacturer.

8.1.2 The contractor or applicator shall provide all materials, tools, equipment (including personnel safety and ventilating equipment) and scaffolding, if specified in their contract.

8.1.3 The contractor or applicator shall use only experienced and qualified manpower to carry out the required works. All manpower shall possess certificates from the lining system manufacturer. Also, the applicator shall appoint a NACE II/BGAS II/FROSIO II certified coating inspector to be responsible for the proper application of the lining system.

8.1.4 The underside of steel floating roofs shall be abrasive blast cleaned or water blasted followed with primer application to remove loose dirt and prevent it from falling and contaminating the wet coating.

8.1.5 Surfaces to be coated shall be inspected and approved prior to any coating being applied. This shall be after surface preparation and between each subsequent coating. No primer or coating shall be applied without approval. The over coating interval time for application of intermediate coat or top coat shall be followed at minimum time period as per manufacturer recommended time interval given in their product data sheets. It is recommended to always avoid the delay in over coating on primer/first coat/intermediate coats. If any such situation occurs in any unforeseen conditions, a mild roughening of the surface by zero grade emery paper would enhance the inter-coat adhesion.

8.1.6 Degreasing and high pressure fresh water washing of partially painted components should take place between coats of paint at the discretion of the client engineer. This is particularly important in offshore situations or in onshore situations where either over coating has been delayed for more than 36 h or the partially painted are seen to be contaminated with dust, oil, grease or particulate matter.

8.1.7 Manufacturer's directions as specified in data sheets shall be followed. The contractor shall have copies of products data sheets and MSDS available at the site where the coating work is being performed.

8.1.8 The client may, at its option, require the contractor to have a technical representative from the coating manufacturer be present to assist and witness the initial and successive application of each coating system. The contractor shall obtain further technical assistance from the coating manufacturer when problems arise or when client requests such assistance at identified key stages.

8.1.9 The application shall be carried out under completely dry conditions and all necessary precautions shall be taken to ensure that water does not come in contact with uncured resin. This is to obtain best adhesion and ultimate chemical resistance of the laminate.

8.1.10 The quality of fibreglass lining work is subjected to approval by client. The contractor shall submit a sample panel for client's shop testing and analysis, as detailed in 6.11.7.

8.1.11 The hand-applied glass fibre mat on the shell shall extend 30 cm minimum on the tank bottom. The lap joint on the tank shell shall be at least 75 cm.

8.2 Safety precautions

8.2.1 Adequate fresh air ventilation shall be provided during all work and for at least four hours after coating application, to keep solvent concentrations within safe, non-explosive limits. Vapours shall be removed by use of an explosion proof air educator, rather than by air blown into the tank.

8.2.2 The coating manufacturer's recommended precautions regarding toxicity and safe handling of all coating materials shall be followed as outlined in MSDS. Special care shall be observed when mixing resins to avoid fire hazards. For coatings which use a promoter, catalyst, and resin (such as polyesters and vinyl esters), the promoter and resin shall be mixed thoroughly before adding the catalyst.

8.2.3 All the personnel involved in the coating work, blasting operators, coating applicators, helpers to operators, supervisors and inspectors shall wear necessary personal protective equipment (PPE). The PPE include hard hats, nose masks, coverall, safety shoes and hand gloves. The gas detectors, H_2S detectors and oxygen monitoring instruments shall be used all times before entering the tanks. Any other equipment and instruments shall be used at site as required.

8.2.4 The contractor shall have a qualified and experienced safety supervisor in the team and available all the time during the execution of the blasting and coating work.

8.3 Areas to be lined (fibreglass lining)

8.3.1 Fibreglass lining shall be installed to the following internal surfaces of tank:

— bottom plates of the entire floor except for potable water tanks;

— shell plates, up to a height as specified in the project specifications/datasheet;

— reinforcing plates under roof support legs and striker plate;

— both sides of the striker plates.

The remaining surfaces shall be coated in accordance with client specification.

8.3.2 Proper coating that is compatible and suitable for services shall be applied with a brush on a nozzle neck to flange weld. The coating shall cover a maximum of 10 mm on the flange face. It is recommended to have 100 mm (4 inch) minimum diameter nozzle for adequate internal coating application.

8.3.3 No sacrificial anodes shall be installed on the fibreglass lining.

8.4 Weather conditions

8.4.1 Fibreglass lining shall not be applied in the following weather conditions:

— ambient temperature: below 10 °C;

— relative humidity (RH): above 85 %;

— dew point: steel temperature is less than 3 °C above the dew point for prevailing environmental condition.

8.4.2 Dew point determination for various ambient air temperatures is explained in Annex A.

8.5 Primer application

8.5.1 If the blasted surfaces cannot be lined completely on the same day, the entire blast cleaned area shall be spray primed with a rapid curing holding primer, before any rust bloom occurs. The DFT shall not exceed 25 µm to 50 µm.

8.5.2 The primer shall be compatible with the lining system to be applied over it. Primers shall be applied under the same conditions and with the same precautions specified by manufacture.

8.5.3 The relative humidity will determine the maximum length of time between blasting and priming.

8.6 Caulking (putty) application

8.6.1 Caulking (putty) compound and seam sealer used shall be as described in 7.4 and specified in the coating system datasheets.

8.6.2 Shallow pits and other sharp irregularities shall be filled with approved putty to a level flush with the plate surface (see Figure B.1).

8.6.3 The putty shall be applied over the primer, and shall be compatible with both the primer and the lining system to be applied over it.

8.6.4 Caulking (putty) compound shall be applied on weld seams, lap joints to provide uniform gradual transition (see Figure B.2).

8.6.5 Large projections and thick plate edges shall be filled with caulking compound in order to smooth out the surface and permit intimate contact with the glass reinforcement.

8.6.6 Caulking compound shall be applied also at the shell to bottom junction to produce a smooth surface on which the fibreglass system is applied without bridging. The applied material at this corner shall have a throat (leg dimension) of 100 mm × 100 mm as explained in Figure B.3.

8.6.7 The above mentioned caulking work can be carried out by spray/brush/trowel, subject to work requirement and technical datasheet.

8.7 Fibreglass laminate application

8.7.1 A production sample plate shall be prepared in line with the application. The plate shall be blasted and primed on the commencement day of internal blasting and final mat and gel coat application shall be on the last day of application.

8.7.2 The glass mat shall be cut to conveniently sized pieces and applied in a staggered seam (patchwork) pattern. Each seam shall overlap a minimum of 100 mm (4 inches). Seams on all vertical surfaces shall overlap the previously applied mat on the bottom. Seams of the second layer (and any successive layers) shall be staggered from the previous layer. Seams of the second layer (and any successive layers) shall be staggered diagonally opposite from the previous layer.

8.7.3 After each mat layer is laid down and saturated with resin, it shall be rolled thoroughly to remove all entrapped air and bubbles and to force the mat down smoothly. A serrated aluminium roller or short bristle brush wet with styrene may be used for this purpose. The direction of rolling or brushing shall be from the centre of the saturated mat outward to prevent trapping air bubbles beneath the mat. If the upper walls (above the fibreglass lining) are to be lined, the intersection area shall be prepared in such a way that the epoxy shall be lapped over the fibreglass lining at minimum 50 mm.

8.7.4 The fibre mat shall cut just before the weld of gusset plate or any other structure welded to shell or bottom plate. The weld joint and the structure part shall be coated with the resin to a height of minimum 600 mm. The intersection area of this resin to phenolic epoxy coating shall be in such a way that always phenolic epoxy shall be coated above the resin.

8.7.5 The resin may be applied either by a special mixing gun or by brush or roller. The first resin coat shall be tinted to indicate coverage over the steel plate. The mixed lining shall be spread, uniformly, on all areas to be covered caulked (e.g. repaired holes, plate overlaps, seams, welds, metal pinholes, etc.).

8.7.6 If a surfacing veil is specified, one 25 µm (1,0 mil) layer of the resin manufacturer's approved veil shall be applied as a final additional layer over the laminate.

8.7.7 When specified on the coating system data sheet, a final wax or gel coat shall be applied over the laminate system.

8.7.8 A final gel coat shall be applied over the laminate system after the complete inspection and repair of the lining.

8.8 Lining thickness

8.8.1 Each individual coat should be checked for wet film thickness (WFT), during application, in accordance with ISO 2808 or ASTM D4414. After application and curing, dry film thickness (DFT) shall be measured with a magnetic/electro magnetic/eddy current film thickness gauge or other equivalent instrument. The measurement shall be in accordance with ISO 19840 or SSPC-PA 2. The DFT gauge shall be calibrated at the beginning of coating work, and then at least three times in a shift of 12 h in a day or whenever recommended by client. The DFT readings shall be recorded and submitted to client for each coat as well as for the total thickness of coating/lining system

8.8.2 The DFT of the coated primer shall be 25 µm at the minimum when measured as per ISO 19840.

8.8.3 The first layer of fibre mat with resin should achieve a minimum thickness of 1 200 µm.

8.8.4 The second layer of fibre mat with resin (1 200 µm) should achieve a minimum thickness of 2 430 µm.

8.8.5 The tissue layer with resin (400 µm) should achieve a minimum thickness of 2 830 µm.

8.8.6 The final gel coat of 250 µm should achieve a minimum total thickness of 3 080 µm.

8.9 Glass flake filled coating application

8.9.1 The surface preparation shall be carried out as per Clause 7 and shall meet all the requirements mentioned in this subclause.

8.9.2 Surfaces to be coated shall be clean, dust free and dry before application of any coating and shall meet the specified anchor pattern and surface finish before application of primer.

8.9.3 No coating shall be applied on damp surfaces; manufacturer guidelines in their datasheet or written procedure shall be followed. The contractor shall have copies of data sheets available at the site where the coating work is being performed. Coatings shall be applied as per manufacturer recommendations for the ambient temperature. The contractor shall obtain and follow the manufacturer's recommendations for over coating drying and curing times at all temperatures.

8.9.4 The coating manufacturer's recommended pot life shall not be exceeded, and when this limit is reached, the spray pot shall be emptied and cleaned, materials shall be destroyed, and new material shall be mixed.

8.9.5 Multi-component systems shall be accurately measured and mixed according to the manufacturer's directions. Mixing shall be done with an air-driven explosion-proof mixer for such time as necessary to ensure that the pigment, vehicles, and thinners are thoroughly mixed. The mixed coatings shall be continuously stirred during application by mechanical spray pot agitators or other approved means, if required by the manufacturer or the client.

8.9.6 All mixing shall be done in clean containers, free from traces of grease, other types of coatings, or other contaminants. Containers shall be cleaned regularly to remove partially reacted solids. All containers shall be kept covered to prevent contamination by dust, dirt, or rain.

8.9.7 Prior to the application of the full coat of primer and each succeeding coat of paint by whatever method, all edges, corners, crevices, welds, holes, bolts, rivets and pitted areas shall be stripe coated with the appropriate paint material by brush, ensuring that the material is worked firmly into the metal surfaces. These stripe coated areas shall extend a minimum of 25 mm from the relevant feature. Roller shall not be used for strip coating.

8.9.8 Each coat shall be applied uniformly and completely using contrasting colour shades over the entire surface according to SSPC Painting Manual Vol. 1 and accepted good coating practice. Care shall be exercised to prevent over spray, spillage, or application of coatings to surfaces for which the coatings are not intended.

8.9.9 The glass flake lining shall be applied in two (2) coats to a minimum dry film thickness of 1 000 µm (40 mils). The maximum Dry Film Thickness shall be the manufacturer's recommended thickness as mentioned in the approved data sheet. Thickness shall not exceed at any point of inspection as per ISO 2808 or SSPC-PA 2.

8.9.10 Dry film thickness shall be checked after each coat is applied, and cured to minimum over coating interval time. The DFT shall not be measured on soft coating surface to avoid erroneous readings.

8.9.11 Coatings shall be applied in no fewer than the number of coats specified, and the dry film thickness of individual coats shall be within the specified thickness range. All coating film thickness shall be checked, and the coating shall be free of pinholes, voids, bubbles, runs or sags, and other detrimental defects. Film thickness is to be measured with a wet film gauge during application. Film thickness shall be checked and maintained during and after each application of each individual coat. Thickness requirements shall be met with each coat and total thickness shall not be achieved in any one coat.

8.9.12 Where film thickness does not meet specifications and or defects (holidays) are found, the contractor shall take corrective action. These corrections shall be to the satisfaction of the client.

8.9.13 All coatings shall be allowed to dry thoroughly and for at least the minimum time recommended by the coatings manufacturer, considering temperature and humidity, before the application of succeeding coats. When a maximum overcoat time is recommended by the coatings manufacturer, it shall not be exceeded before the succeeding coat is applied.

8.9.14 Prior to the application of any coat, all damage to previous coats shall be repaired.

8.9.15 Each coat (primer, intermediate coats, and topcoat) shall be inspected before applying further coats.

8.9.16 Glass flake reinforced coatings shall be spray-applied, according to the Coating System Data Sheet and the client approved application procedure. The coating shall be applied in two or more coats to obtain the specified thickness. The airless spray method/plural component airless equipment is the recommended methods to provide the best adhesion of coating on the metal surface. Brush can be used only for repair of small areas.

8.9.17 Spray-applied coatings can be rolled, if approved by the client or stated in the Coating System Data Sheet.

8.9.18 After application of the complete coating system, it shall be allowed to fully cure as per the manufacturer's recommendations before the component is handled or moved. If the coating does not cure within the recommended period, a sample shall be removed to ascertain the cause of the problem.

8.9.19 A sample test coupon shall be prepared simultaneously and handed over to the client for further tests after marking the name of contractor and the date of application punched on the same.

8.10 Thin film coating application

8.10.1 The surface preparation shall be carried out as per Clause 7 and shall meet all the requirements mentioned in this subclause.

8.10.2 The coating shall be mixed in proper ratios as per the manufacturer's recommendations and no part mixing shall be allowed.

8.10.3 No thinning shall be allowed more than the manufacturer's recommendations. For potable water tank lining, thinner shall not be used at any case. Stripe coat shall be applied on all weld areas, sharp corners and all the areas where it is not practical to apply by spray.

8.10.4 Spray coat shall be applied at recommended pressure using the right spray tip size in order to be able to control the WFT thickness. Manufacturers recommended over coating or recoating intervals shall be strictly followed.

8.10.5 If the thickness found more than the manufacturer's recommended range, re-blast and reapply the lining system to the specification.

8.10.6 A sample test coupon shall be prepared simultaneously and handed over to client for further tests after marking the name of contractor and the date of application punched on that.

8.10.7 The minimum thickness for each type of coating shall be as per Table 4.

Table 4 — Minimum thickness for thin film coatings

System	N° of coats	Thickness per coat µm	Total thickness[a] µm
Phenolic epoxy	3	100	300
Novolac epoxy	2	250	500
High build epoxy	2	200	400
Solvent free epoxy	2	200	400
[a] Without the thickness of surface holding primer.			

8.11 Curing

8.11.1 Fibreglass reinforced lining shall be allowed to cure in well ventilated dry conditions and in accordance with the manufacturer's instructions for curing, after successful inspection and before the tank or vessel goes into in service.

8.11.2 Curing time shall be dependent on ambient temperature only and shall be as per recommendations by the manufacturer.

9 Inspection and testing

9.1 General requirements

9.1.1 The applicator shall perform inspection and testing during the application in accordance with client approved inspection and testing plan (ITP) to verify the surface preparation, coating/lining application and the specified properties of the applied coating/lining. The ITP shall be prepared by the applicator and shall be reviewed and approved by the client prior to the start of the coating work. The ITP shall identify all inspection activities and tests, their frequency and the relevant inspection authorities. The plan shall include all activities in chronological manner and shall have columns for marking up client, witness (W), hold (H) and review (R) points.

9.1.2 Inspection and testing at all stages of surface preparation and lining application shall be conducted by the applicator or as agreed by the client to ensure compliance with the requirements of this International Standard.

9.1.3 Surface preparation and lining application may be subjected to inspection at any stage to ensure the compliance with all requirements of this International Standard. All records, inclusive of products and procedures used during the installation of the lining shall be kept current and shall be submitted to the client upon request, or on daily/weekly basis, and at the completion of the job for verification to client satisfaction.

9.1.4 A client representative shall have the right to inspect at all times any tools, materials or equipment used in the performance of surface preparation and lining application.

9.1.5 The coating manufacturer's representative shall have access to the work site during the progress of the work, for any inspection and testing deemed to be necessary to ensure that coating/lining system is properly applied.

9.1.6 Any surface preparation or coating/lining work which does not satisfy the requirements of this International Standard shall be re-done by the contractor or applicator.

9.2 Environmental conditions testing

At the beginning of each day's operation and prior to the commencement of any coating/lining application work, ambient temperature, metal surface temperature and relative humidity (RH) shall be measured and recorded. Readings shall comply with 7.5. The surface to be coated/lined shall be inspected to verify that no moisture is present.

9.3 Materials and equipment inspection

9.3.1 Abrasive blasting and fibreglass lining application equipment (airless spray pump, hoses, etc.) shall be inspected to ensure the compliance with the requirements of this International Standard and the manufacturer's recommendations.

9.3.2 The contractor shall submit a list of QA/QC equipment intended to be used for internal coating/lining along with calibration certificates. The client shall confirm accurate working of inspection tools available at tank worksite.

9.4 Compressed air and abrasive

9.4.1 The cleanliness of each compressed air supply shall be verified daily by blasting without abrasive or coating onto blotting paper for 20 s. If oil or water appears on the blotting paper, all traps and separators shall be blown down until subsequent 20-s blotting tests in accordance with ASTM D4285 show no more oil or water.

9.4.2 The abrasive used shall be free of contaminants such as water soluble salts, dirt, clay, oil, grease and other foreign materials (per SSPC-AB1, SSPC-AB2, and ASTM D4940). If present in the blasting media, contaminant may be delivered to the steel surface during cleaning operations and subsequently reduce the useful life of the lining.

9.4.3 Re-circulated abrasives shall be tested for oil contamination via test at least twice per shift by the immersion of a small amount of abrasive in a vial of water which is shaken vigorously. If any oil floats to the surface, the abrasive shall be discarded. Also, dust shall be removed from re-circulated abrasives to meet environmental regulations and to improve cutting efficiency. Recycled abrasive shall be tested for chlorides.

9.4.4 Cleanliness of the abrasive shall be tested in accordance with ISO 7027. Maximum reading for turbidity is 25 NTU.

9.5 Surface preparation inspection

9.5.1 Surfaces to be coated/lined shall be inspected to verify that specified surface preparation requirements have been achieved as per 9.5.2 to 9.5.5.

9.5.2 Prior to abrasive blasting, the steel surface shall be checked for the presence of defects and contaminants (e.g. oil/grease, sand/dust, weld spatter, weld slag.)

9.5.3 After abrasive blast cleaning, the steel surface shall be inspected for visual standard (surface cleanliness) and surface profile. The visual standard shall be Sa 3 white metal (new steel) and Sa $2\frac{1}{2}$ near white metal for maintenance work, in accordance to ISO 8501-1. The surface profile shall be as per manufacturer's recommendations or this International Standard. Testing of surface profile height shall be in accordance with ISO 8503, ASTM D4417 or NACE RP0287. The measurements and results shall be recorded and submitted for the client's approval.

9.5.4 The blast cleaned surface shall be checked for the presence of soluble chloride in accordance with ISO 8502-6 and ISO 8502-9, or SSPC-Guide 15, or as per client approved standards and test equipment. The chloride contamination shall not exceed 20 mg/m^2 or as specified by coating system datasheet. Testing for the presence of sulphates per ISO 8502-11, SSPC-Guide 15, or equivalent industry approved methods, should be made. If the surface exceeds the above limits or recommend limits of manufacturer's data sheets, the blast cleaned surface shall be water washed in accordance with 7.3.5 or repeated.

9.5.5 The dust embedded on the cleaned surface shall not exceed grade 2 of ISO 8502-3.

9.6 Coating/lining inspection and testing

Coated/lined surfaces shall be inspected/tested in accordance with 9.7 to 9.11 to verify that the specified coating/lining quality and thickness have been achieved. Test methods, frequencies and acceptance criteria are specified in 9.7 to 9.11.

9.7 Coating/lining film thickness

9.7.1 The DFT of coats/lining shall be measured in accordance with ISO 19840/SSPC-PA-2.

9.7.2 The recommended minimum DFT of each system shall be as presented in Table 5.

Table 5 — Minimum DFT for coating/lining

System	No. of coats	Thickness per coat µm	Total thickness[a] µm
Fibreglass lining	3 (2 MATS + ISSUE + GEL COAT)	(2 × 1 200) + 400 + 250	3 050
Glass flake filled coating/ lining	2	500	1 000
Phenolic epoxy	3	100	300
Novolac epoxy	2	250	500
High build epoxy	2	200	400
Solvent free epoxy	2	200	400
[a] Without the thickness of surface holding primer.			

9.8 Holiday detection test

9.8.1 The fully applied and cured fibreglass and glass flake lining system shall be electrically (spark) tested for pinholes and holidays using an approved high voltage spark type holiday detector. This shall be carried out over the entire (100 %) lined surface. The holiday testing shall be carried out in accordance with ISO 29601 or NACE SP0188, and manufacturer's recommendations. This testing shall be carried out before gel coat is applied.

9.8.2 The applied fibreglass lining shall be 100 % porosity free. Small and limited number of pinholes may be permitted for repair in accordance with 9.10, provided that the contractor and client agree on the acceptable level within contract documents.

9.8.3 The thin film coating shall be pinhole tested by wet sponge method as per ISO 29601 or NACE SP0188.

9.9 Curing hardness test

9.9.1 The fibreglass lining layer shall be tested for curing by barcol hardness tester in accordance with ASTM D2583, at 10 different locations or as required by client prior to the application of gel coat. The average reading should be as recommended by the manufacturer. The minimum and maximum and average readings shall be recorded in the test record.

9.9.2 The surface cure shall also be tested. If the resin surface still soft or tacky, the surface is un-cured.

9.10 Defects and pinhole repair

9.10.1 Following the complete curing, any defect/pinhole observed after spark test shall be marked for repair with or by grease free chalk. Permanent marker shall be agreed.

9.10.2 Areas containing holidays shall be completely removed by power tool as per SSPC-SP 11 to base metal, re-coated/lined with the same system in accordance with this International Standard and the manufacturer's recommendations (detailed procedure shall be prepared by the contractor for approval).

9.10.3 The repaired areas shall be re-tested for holidays. Detected holidays, correction, and final holiday-free inspection shall be recorded and submitted for approval.

9.10.4 It is mandatory that defective work shall be corrected to the satisfaction of the controlling standards and specifications. Work shall not be deemed to be completed until the foregoing has been achieved.

9.11 Adhesion test

An adhesion test on the prepared sample plate during the application of the tank lining shall be carried out as per ISO 4624 or ASTM D4541 after immersing the sample plate in water (60 °C) for 24 h. If the service is for more than 60 °C and different service liquid, the same shall be used for the test method to represent the actual immersion conditions.

10 Quality requirements

10.1 The manufacturer/contractor should operate a quality management system to satisfy the requirements of this International Standard (e.g. based on the ISO 9000- series or ISO/TS 29001).

10.2 Prior to commencement of work, the contractor shall submit its QA/QC documentation for approval as per the requirements of the client. This shall include the quality plan and quality control system including, inspection and testing methods and reporting/recording formats.

10.3 The contractor shall prepare and submit to its client for approval a detailed procedures manual of all work, sufficiently in advance before commencement of outlining, but not limited to, the following:

10.3.1 Manufacturer's details, equipment full details, characteristics, data sheets and test certificates.

10.3.2 Full details of past projects records of proposed surface preparation and lining applications. Such information shall include the name of the project, service conditions and any other details required by the client.

10.3.3 Certificates from a testing laboratory operating in accordance with ISO/IEC 17025, that the materials and equipment used in surface preparation and coating/lining application meet or exceed the requirements of this International Standard and the client requirements.

10.3.4 ITP for surface preparation and coating/lining applications shall satisfy the client's requirements.

10.3.5 Sample log sheets of material receipts, measurements, logging, and dispatches.

10.4 The work/supply shall commence only after approval of the quality system procedures manual and supply datasheets. After approval, any changes made shall be authorized, in writing, by the client.

10.5 Only suitably skilled and experienced personnel shall be used to meet the required duties in this International Standard. CVs of these personnel shall be provided for client approval. Adequate supervision shall be employed at all times.

10.6 The client may conduct a quality audit at the Manufacturer's/Suppliers/contractors facilities at any stage during work execution or supply.

11 Documentation

11.1 General

11.1.1 All dimensions, units of measurement, physical constants, etc. shall be in SI units, unless otherwise specified.

11.1.2 All documents, (texts, specifications, data sheets, etc.) shall be provided with electronic files in the approved software. Design calculations shall be submitted in the approved and widely used software, agreed by client.

11.2 Work proposal

The contractor shall submit its proposal for all aspects of work, for the approval of the client prior to commencement. This includes the following:

11.2.1 Information on work location, fibreglass lining/glass flake filled coating/thin film coating materials, equipment to be used, items on surface areas to be lined, surface preparation, lining application procedure(s) etc.

11.2.2 Technical drawings of the equipment to be lined showing the fibreglass lining details of internal surfaces.

11.2.3 Manufacturer's technical data sheets, material performance certificates and test approvals shall be provided for all lining materials.

11.2.4 Documents related to evaluation of all hazards and provision of proposals in order to meet HSE requirements and Material Safety Data Sheet (see Clause 5).

11.2.5 Inspection/testing plans, procedures and equipment including training certificates of applicators.

11.2.6 Specific repair proposal to satisfy the requirements of 9.10 for small pinholes and other defects repair.

11.3 Work records/reports

11.3.1 The contractor shall operate a comprehensive recording and reporting system on all aspects of the lining work including inspection/testing. The data shall be set out on a lining work record/datasheet and inspection/testing record within 24 h of carrying out a specific work.

11.3.2 Samples of the data sheet and record are shown in Annex C and Annex D.

11.4 Inspection and testing reports and certificates of compliance

The inspection documents shall be in accordance with ISO 10474 (EN 10204). The type of certificate of compliance shall be defined by the client. The certificate of compliance shall be issued by the applicator, which provides the results from the inspection and testing of the coated/lined internal tank surfaces in accordance with the requirements of this International Standard and any other requirements specified by the client. If, however, the client does waive the requirement for an inspection certificate, then the applicator should provide a certificate of compliance of inspection and testing reports with the requirements of this International Standard. The certificates of compliance signed by the applicator (and the inspector, if applicable) shall be transmitted to the client at a frequency defined in the purchase order. Cumulative production records shall be maintained daily.

11.5 Final report

Photographic and written report shall be submitted on completion of the lining work. The final report shall include a summary on all aspects covered example, surface preparation, lining application procedure and inspection and testing records performed.

Annex A
(informative)

Dew point calculation chart

Table A.1 shows a dew point calculation chart.

Table A.1 — Dew point calculation chart

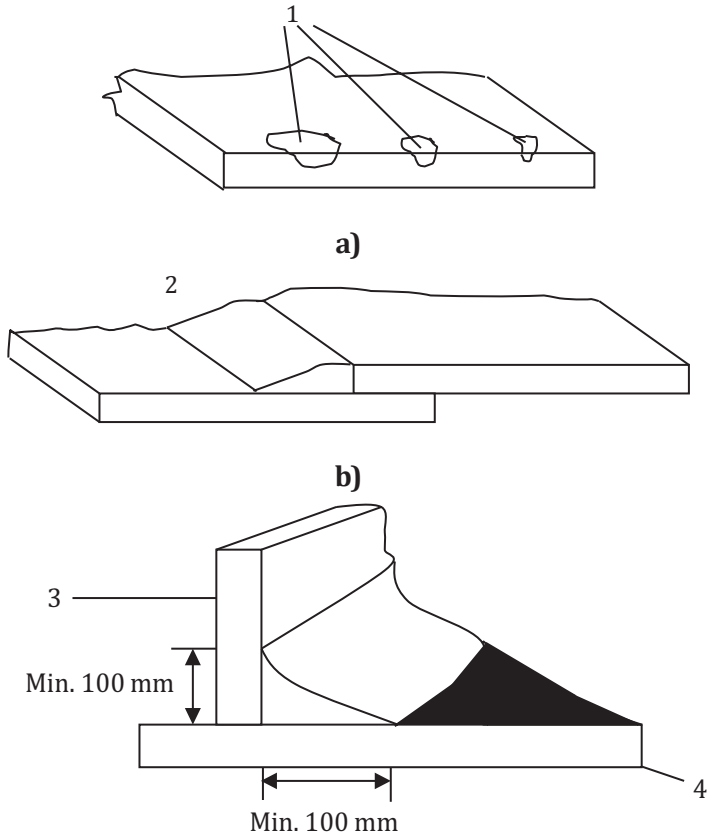
RELATIVE HUMIDITY %	**AMBIENT TEMPERATURE** °C										
	–7	–1	4	10	16	21	27	32	38	43	49
90	–8	–2	2	8	14	19	25	30	36	41	47
85	–9	–3	2	8	13	18	24	29	35	40	46
80	–10	–4	1	7	13	17	23	28	34	39	45
75	–11	–5	0	6	12	16	22	27	33	38	43
70	–12	–6	–1	5	10	15	21	26	32	36	42
65	–13	–7	–2	4	9	14	20	25	30	35	41
60	–14	–8	–3	3	8	13	19	23	29	34	39
55	–15	–9	–4	1	7	12	17	22	27	32	38
50	–16	–10	–6	0	6	10	16	20	26	30	36
45	–17	–12	–7	–1	4	9	14	19	24	29	34
40	–18	–13	–9	–3	2	7	12	17	22	27	32
35	–20	–15	–10	–5	0	5	10	15	20	24	30
30	–22	–17	–12	–7	–2	3	8	12	18	22	27

EXAMPLE If the air temperature is 27 °C and the relative humidity is 50 %, the dew point is 16 °C. Blasting and lining should be made at a minimum steel temperature of 16 °C + 3 °C = 19 °C.

Annex B
(informative)

Caulking (putty) application

Figure B.1 shows schedules for caulking (putty) application.



Key

1	surfacer
2	surfacer
3	shell
4	bottom plate

Figure B.1 — Schedules for caulking

Annex C
(informative)

Example of coating/lining work record/data sheet

Item(s) to be lined _____ ____ Drawing No _____ Tank/Vessel No _____
Surface area(s): Bottom _____ Shell _____ Others _____ Location _____
New / Maintenance Work _____
Project / Contract No _____ Date _____
Contractor name _____ Applicator name _____

A Surface preparation

Surface repair(s)
1 _____
2 _____

Cleaning method(s)
1 _____
2 _____

Surface cleanliness _____
(visual standard)
Surface condition _____ Abrasive type _____
Surface profile height _____ Abrasive sieve size _____
(micron)

B Weather conditions

Ambient temperature (°C) _____ Surface temperature (°C) _____
Relative humidity (%) _____ Dew point _____
Wet / dry / hot surroundings _____ Other weather conditions _____

C Coating/lining materials

1. Primer type _____ Manufacturer _____ Trade name _____
2. Caulking (putty) compound type _____ Manufacturer _____
3. Resin type _____ Manufacturer _____
4. Hardener type _____ Manufacturer _____
5. Trade name (resin and hardener) _____
6. Mixing ratio _____
7. Matt / Flake type _____ Manufacturer _____ Matt weight (gm/m) _____
8. Surface tissue (ST) type _____ Manufacturer _____ ST weight (gm/m) _____

D Coating/lining application

1. Primer application – Brush / Roller / Airless spray _____
2. Airless tip size / Angle (thou/deg) _____
3. Pump type & Ratio _____
4. Lining application procedure _____
5. Curing period _____

Prepared by _____ Checked by _____

Signature _____ Signature _____
Date _____ Date _____

Annex D
(informative)

Example of coating/lining inspection and testing data sheet

Project / Contract No _____ Date _____
Contractor name _____ Applicator name _____

Application method _____
Materials used _____

1 Surface preparation testing

- Visual standard _____
- Profile height _____
- Surface contaminants free test _____

2 Applied lining test results

- Lining surface appearance _____
- Average lining thickness (microns) _____
  At 10 different locations
- Holiday detection results _____
- Barcol hardness (934 -1 average readings
  At 10 different locations (at 21 °C) _____
  Minimum _____ Maximum _____ Average _____
- Be nding test results
  Fiberglass surface
  Upward _____

Remarks

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