INTERNATIONAL STANDARD

ISO 21809-11

First edition
2019-04

Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems —

Part 11: Coatings for in-field application, coating repairs and rehabilitation

Industries du pétrole et du gaz naturel — Revêtements externes des conduites enterrées ou immergées utilisées dans les systèmes de transport par conduites —

Partie 11: Réparations et réhabilitation du revêtement sur site

Reference number
ISO 21809-11:2019(E)

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Published in Switzerland

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 2, *Pipeline transportation systems*.

A list of all the parts in the ISO 21809 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The objective of this document is to define the technical requirements for corrosion protection by the coating of external surfaces of carbon steel pipes that are used in oil and gas industry and have the need for a coating replacement or repair to be performed on site (corrosion protection for other metallic pipes should be considered on an individual basis). This document also provides technical guidance for developing project specifications and to ensure conformance in coating material selection and performance with contract requirements.

Users of this document should be aware that further, or differing, requirements can be needed for individual applications. This document does not limit contractors and manufacturers from proposing, or the purchaser from accepting, alternative engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is proposed, the specification issuer should identify any deviation from this document and provide details.

Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems —

Part 11: Coatings for in-field application, coating repairs and rehabilitation

1 Scope

This document specifies the criteria and requirements for the in-field application of coatings, coating repair and coating rehabilitation on buried pipelines.

This document specifies:

— coating assessment (new and existing);

— removal of degraded coatings;

— surface preparation;

— on site or in situ application of external coatings.

It is applicable to petroleum or natural gas pipelines, with or without a cathodic protection system.

The pipelines could be operational during the removal, preparation and application process.

This document states qualification/testing for field contractors and site applied coatings to all of the pipeline components, including bends, tees, fittings, valves and interfaces between different coatings in soil-to-air pipeline sections.

Technical and performance characteristics of the repair and rehabilitation coating materials are referenced to ISO 21809-3.

The coating of field joints is outside the scope of this document. Field joint coatings are dealt with in ISO 21809-3.

This document excludes the application of coatings when the pipeline is immersed (submerged).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 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 conductometric determination of water-soluble salts*

ISO 8503-4, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile — Stylus instrument procedure*

ISO 8503-5, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates — Part 5: Replica tape method for the determination of the surface profile*

ISO 10474:2013, *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 21809-3, *Petroleum and natural gas industries — External coatings for buried or submerged pipelines used in pipeline transportation systems — Part 3: Field joint coatings*

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

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

SSPC-SP1, *Surface preparation specification No.1 — Solvent cleaning*

NACE SP0287, *Field Measurements of Surface Profile of Abrasive Blast-Cleaned Steel Surfaces Using a Replica Tape*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21809-3 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
application procedure specification
APS
document describing procedures, methods, equipment and tools used for coating application

3.2
applicator
organization, contractor or subcontractor having the technical capability, knowledge, equipment and qualified personnel that is approved by the purchaser for the coating processes as required by this document

3.3
coating operative
individual undertaking coating activity on the work site, including surface preparation

3.4
contractor
company that agrees to furnish materials and/or perform specific services to the purchaser

3.5
inspection and testing plan
ITP
document providing an overview of the sequence of inspections and tests, including resources, procedures and acceptance criteria

3.6
inspection document
document stating conformance with the requirements given in the purchase order

Note 1 to entry: This document is in conformance with ISO 10474:2013.

3.7
purchaser
company responsible for providing the product order requirements and for approving and possibly making the appropriate selection of the repair or rehabilitation coating, including preparation and application method

3.8
rehabilitation
<coating> activity performed on a pipeline, including:

1. assessment of the existing coating
2. removal of the existing coating
3. preparation of the surface on which the new coating is applied
4. application of a new coating

in order to reach a level of corrosion protection that enables a metallic structure to continue in service operation safely and economically

3.9
repair
<coating> activities dedicated to restore the integrity of the coating when the damage are localized on small areas

Note 1 to entry: Typically these activities are performed manually.

3.10
total coating thickness
thickness of a coating system, including all the layers, after installation is completed

Note 1 to entry: For liquid coatings, this can be Dry Film Thickness (DFT), which is the thickness of a cured coating system after installation is completed.

4 Abbreviations

AC	Alternating Current
ACVG	Alternating Current Voltage gradient Survey
APS	Application Procedure Specification
ASTM	American Society for Testing &Materials

BIT	Bitumen based coating
CP	Cathodic Protection
DC	Direct Current
DCVG	Direct Current Voltage Gradient Surveys
EP	Epoxy based coating
FBE	Fusion Bonded Epoxy
FC	Field Coating (System)
HSE	Health, Safety and Environment
HSS	Heat Shrinkable Sleeve
ILI	In Line Inspection
ITP	Inspection and Testing Plan
MIC	Microbiological Induced Corrosion
PE	Polyethylene
PP	Polypropylene
PPT	Pre-Production Trial
PQT	Procedure Qualification Trial
PU	Polyurethane based coating
RH	Relative Humidity
RP	Recommended Practice
PDS	Product Data Sheet
SDS	Safety Data Sheet
SSPC	The Society for Protecting Coatings
TDS	Technical Data Sheet, also known as PDS
VOC	Volatile Organic Compounds

5 General requirements

5.1 Responsibility of the purchaser

The purchaser shall be responsible for approving and possibly making the appropriate selection of the repair or rehabilitation coating, including application and surface preparation methods, in accordance with the expected working, environmental and service conditions.

The general responsibilities map is given in Figure 1.

5.2 Rounding

Unless otherwise stated in this document, 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[1)].

NOTE For the purposes of this provision, the rounding method of ASTM E 29 is equivalent to ISO 80000-1:2009, Annex B, Rule A.

5.3 Conformity to requirements

Systems for quality and environmental management, and the competence of testing and calibration laboratories, should be applied to assist conformity with the requirements of this document.

1. ISO/TS 29001 gives sector-specific guidance on quality management systems.

2. ISO 14001 gives requirements with guidance for the use of an environmental management system.

3. ISO/IEC 17025 gives general requirements for the competence of testing and calibration laboratories.

The applicator shall be responsible for complying with all the applicable requirements for the application of this document. The purchaser shall be allowed to make any investigation necessary to ensure conformity by the applicator and to reject any material and/or coating that does not comply.

6 Information to be supplied by the purchaser

6.1 General information

The purchase order shall include the following information:

a) designation of this part of ISO 21809 and year of publication (ISO 21809-11:2019);

b) type of field coating system(s);

c) minimum and maximum thickness of the field coating (if applicable);

d) minimum and maximum operating and design temperature of the pipeline;

e) type of pipe (seamless or welded with longitudinal or helical seam, material/grade);

f) pipe nominal outer diameter and wall thickness;

g) existing coating system(s), including thickness(es);

h) technical specifications/data sheets and inspection/testing result/reports of the existing coating system;

i) length of pipe or pipeline component to be coated;

j) pipeline geometry (bends, fittings, other pipeline components);

k) site conditions (accessibility, etc.);

l) type and frequency of inspection document in accordance with ISO 10474:2013 (or EN 10204:2004) .

1) Under preparation. Stage at the time of publication: ISO/DIS 80000-1.

6.2 Additional information

The purchase order shall specify which of the following provisions apply for the specific order item:

a) coating material qualification trial and parties to be involved;

b) permissible coating repairs;

c) acceptable level of soluble salts;

d) any special requirement with regard to FC overall thickness and/or thickness of individual layers;

e) overlap on the existing (e.g. “plant-applied”) coating or detailed drawing of the field coating with dimensional tolerances;

f) requirements for traceability and marking;

g) requirements for documentation and schedule of supply of documentation;

h) qualification of the applicator's personnel who apply and/or inspect the coating;

i) purchaser’s approval of the application procedure specification (APS);

j) use of specific proprietary coating materials;

k) additional mechanical protection;

l) procedure qualification trial (PQT) and parties to be involved;

m) pre-production trial (PPT) and parties to be involved;

n) technical support required from manufacturer;

o) subsequent coating (or infill) being applied;

p) environmental conditions during surface preparation, application, curing, backfilling;

q) status of the pipeline (e.g. operational or gas in transit);

r) specific surface conditions at the moment of surface preparation and coating application;

s) method of (re)installation of the pipeline;

t) time constraints for application and number and dimensions of working stations, if relevant;

u) specific testing conditions and minimum requirements if different from those of ISO 21809-3 and this document;

v) backfilling, e.g. material and methodology.

7 Qualification processes and application procedures

7.1 General

The qualification process is consists of the following steps from A to D:

a) the qualification of coating materials, that shall be qualified by the manufacturer (see 7.1.1),

b) the qualification of applied coating system, that shall be qualified by the applicator (see 7.1.2),

c) the APS, that shall be validated, if required, by a Procedure Qualification Trials (PQT) (see 7.1.3),

d) the inspection at the Pre-Production Trials (PPT) and during production, that shall be performed according to an approved Inspection and Testing Plan (ITP) (see 7.1.4 and 7.1.5).

Of the above steps A, B and D are mandatory while C shall be specified by the purchaser.

Those parts of the qualification process that are waived by the purchaser, shall be clearly stated and identified in the contract.

The overall qualification and responsibilities map and its application to the several steps of the rehabilitation activities, is represented in Figure 1.

7.1.1 Coating material qualification, by the manufacturer (coating materials qualification)

Each coating material shall be qualified by the manufacturer in conformance with the requirements of ISO 21809-3 or other agreed standards. The manufacturer shall qualify and report the coating material qualification in accordance with the requirements, where applicable. The test report issued by the manufacturer may be also verified by an end user.

The qualification shall be repeated every five years and in case of changes in the material composition, the production process that influence the material processing behaviour or a change in the production facility.

The test report shall contain the results of the qualification tests and the technical data required by the purchaser, see also 7.6.

7.1.2 Qualification of the coating system, by the applicator (coating system qualification)

The applicator, receiving the manufacturer's test report, shall verify that it meets the requirements of ISO 21809-3 or other agreed standards requested for the coating material. The applicator shall also review the coating selection considerations of this document.

Each coating system shall be qualified by the applicator. The applicator shall prepare an APS (see 7.2) and an ITP (see 7.5) related to the qualification of the specific coating system.

Where applicable the applicator shall carry out and report the coating qualification in accordance with the requirements. The test report shall contain the results of the qualification tests and requirements.

7.1.3 Procedure Qualification Trials (PQT) if requested by the purchaser

In case a PQT is requested, a specific ITP shall be prepared and implemented for the PQT. See 7.3 (PQT) and 7.5 (ITP).

7.1.4 Pre-Production Trial (PPT)

Before production starts, a PPT shall be performed according to a dedicated ITP. A specific ITP shall be prepared and implemented for the PPT. See 7.4.

7.1.5 Production test

A specific ITP shall be prepared and implemented for the Production activity. See 7.5.

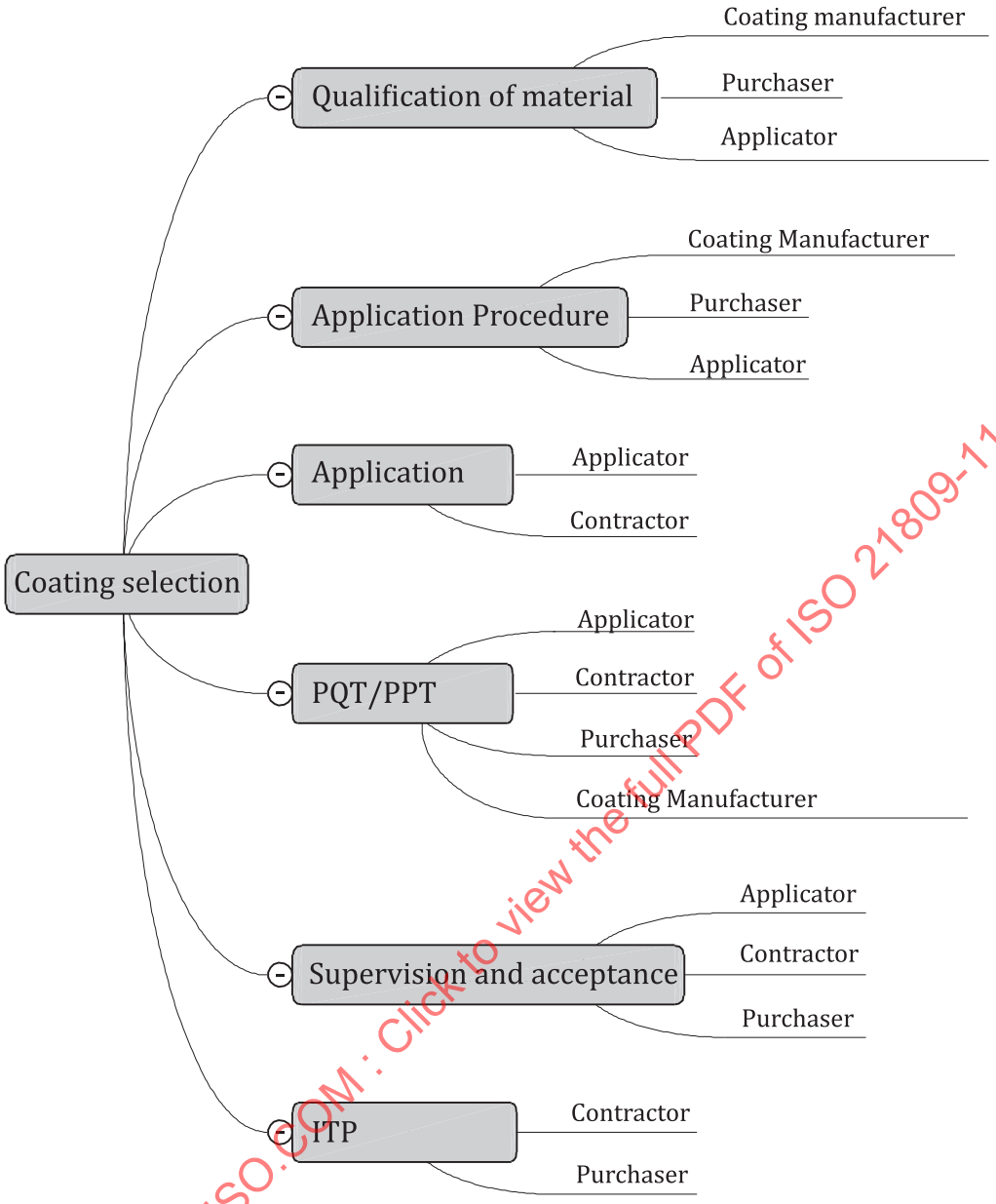


Figure 1 — Responsibility map

7.2 Application Procedure Specification (APS)

The APS shall be prepared by the applicator and made based upon the coating manufacturer's TDS, SDS and application instructions. Before usage and before any PQT/PPT, the APS shall be approved by the purchaser. Once approved, the APS shall not be changed without prior written authorization of the purchaser.

The responsibilities shall be clearly described between all involved parties.

The APS shall be coating system specific.

The APS shall cover all items associated with quality control as defined in this document and any agreed options for the specific FC.

All coating work, testing and inspection shall be carried out according to the APS.

The application procedure shall address at least the following, as applicable:

a) coating material identification;

b) tools, consumables, and equipment required to apply the coating system;

c) equipment set up and calibration;

d) approved solvents or other cleaning agents to be used to clean the steel and adjacent anticorrosion coating prior to surface preparation;

e) surface preparation of the steel (including final surface profile, materials and surface contamination mitigation);

f) surface preparation of existing anti-corrosion coatings (e.g., cutback, bevel, repairs and precaution measures, when necessary);

g) compatibility with existing anti-corrosion coating;

h) preheating methods, for existing coating and rehabilitation/repair coating material;

i) substrate temperature range for surface preparation, application and cure;

j) ambient conditions considering dew point temperature at the surface to be coated;

k) coating mixing , pot life and thinning procedures;

l) coating thickness range;

m) coating application method;

n) coating curing or cooling schedule and conditions;

o) overcoat time and repair method;

p) time to inspection;

q) time to backfill;

r) handling and storage requirements for coating materials, including the following, as applicable:

   1) temperature limitations (e.g., freezing, excessive heat);

   2) humidity;

   3) protection from the elements (e.g., snow, rain, sunlight);

   4) protection from contaminants (e.g., dust, water, chemicals);

   5) expiration date;

   6) protection from physical damage.

7.3 Procedure Qualification Trial (PQT)

If specified by the purchaser, the APS shall be validated by a PQT. Test methods and frequencies suggested for PQT are identified in Annex A and shall be reported in a dedicated ITP. Acceptance criteria are given in the relevant clauses referred to in Annex A.

The main purpose of the PQT shall be to demonstrate that the provided surface preparation and application procedure, equipment and personnel (or the level of skills required for the personnel that will be undertaking the coating application) are able to apply the coating in accordance with the purchaser/specification/manufacturer's requirements to achieve the stated performance of the coating. The PQT is not intended to validate the selection of the coating.

If performed by the same contractor, the evaluation of the method intended to be used for the removal of the deteriorated/damaged coating shall be part of the PQT in order to verify that the selected method does not cause damage to the metallic substrate. HSE issues for coating removal should also be addressed in the same PQT.

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

The PQT can be carried out independently of any project. In this case, representative pipes having the diameter, thickness and plant-coating as agreed upon between manufacturer, applicator, and purchaser shall be used.

For a PQT related to a specific project, tests shall be carried out on test zones distributed along a pipe coated with the actual coating. The length of the test zones shall be such that it allows the specific surface preparation and coating application peculiar to a specific coating and represents the settings for onsite/field operations. The test location shall be defined in the PQT program.

Unless otherwise agreed, the conditions during PQT shall reflect all the conditions (e.g. ambient temperature, wet/dump surfaces, immersion, etc.) anticipated during the actual project.

If not present, a weld should be added at the centre of each of the test zones to simulate any welds (girth and or longitudinal or helical).

If heating of the area to be coated is specified in the APS, it shall be demonstrated that there is at least no detrimental effect such as blistering or disbondment of the existing coating to be overlapped.

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

Coating repairs and stripping of defective FC shall be included in PQT (except if coating repairs are not allowed).

The time for coating application during PQT shall be consistent with the estimated coating time in the field. Any significant differences in the PQT environment compared to actual production conditions should be considered, e.g. number of work stations, similarity of, or differences in, lifting equipment.

The tests shall be repeated whenever a modification to equipment, to material composition or any other production process, affecting the specified characteristics. This includes the line crew.

The applicator shall submit a complete report of the qualification test results to the purchaser for approval.

7.4 Pre-Production Trial (PPT)

To verify conformity with the project requirements a PPT shall be performed on site, before production starts. It shall at least include the following:

a) surface condition and adhesion of the existing coating on steel in the area to be overlapped by the rehabilitation coating;

b) field coating materials;

c) surface preparation and application procedure;

d) equipment being used for surface preparation and coating application;

e) heating equipment (when used);

f) application of the coating system;

g) qualification of the coating operatives and inspectors who will undertake the work;

h) properties of the applied FC.

The above shall comply with the requirements of any previous PQT.

Test methods and frequencies for PPT are specified in Annex A. Acceptance criteria are given in the relevant clauses to which reference is made in Annex A.

The PPT shall be carried out in the presence of the end user and/or purchaser (or their representative) at the start of operations when equipment and personnel are mobilized on site. The PPT shall be performed on the first length of pipe or component to be coated (or, if agreed, on a dummy pipe).

The applicator shall submit a complete report of the tests containing the values and other results obtained in the PPT.

7.5 Inspection and Testing Plan (ITP)

A dedicated ITP shall be prepared by the applicator for all the process steps (PQT, PPT, production) and the contents shall reflect all the process items, the items to be inspected and tested (and frequency thereof) and acceptance criteria as described by the APS.

At least the following activities shall be listed:

a) Description of the activities;

b) Identification of coated item and substrate;

c) Selected coating system;

d) Inspection points for each of the activities;

e) Applicable reference documents;

f) Applicable check procedures and methods;

g) Acceptance criteria;

h) Frequency of the checks;

i) Remedial actions;

j) Persons required to be present at the inspections;

k) Reporting.

7.6 Coating materials

The applicator shall provide the data sheets and information specified in the following, for each coating material from the manufacturer:

a) product technical data sheet (PDS);

b) application instructions, including compatibility with other coatings;

c) batch certificates;

d) packaging, transport and storage requirements of coating materials;

e) range of application conditions including minimum and maximum application temperatures (for materials and substrate) and relative humidity;

f) safety data sheets (SDS).

To minimize the risk of incorrect material selection for application in the field the product shall be clearly labelled. As a minimum, the shipping documents and labels shall include information that will ensure the traceability of the product post-application. In this sense key information could be:

— Project reference;

— Purchase order number;

— Product name;

— Unique product identifier;

— Batch number;

— Storage conditions;

— Shelf life;

— Expiry date.

7.7 Qualification of coating and inspection personnel

7.7.1 General

The coating operatives shall be qualified to undertake the coating application procedure and repair work. The qualification shall be obtained by demonstration at a PQT (if any) or during PPT, or via a third party organization, as agreed with the purchaser.

The applicator may request the manufacturer of the coating material(s) and equipment to provide technical assistance to the coating operatives if necessary.

Proof of successful qualification shall be documented.

Inspectors carrying out the coating inspection shall be trained and qualified.

The inspector competency shall be proven by attested experience, specific training by the manufacturer or by the certification body in conformity with certification schemes approved by the purchaser, e. g. NACE, FROSIO (The Norwegian Professional Council for Education and Certification of Inspectors for Surface Treatment), SSPC, DVGW GW 15 (Deutsche Verein des Gas und Wasserfaches — Nachumhüllungen von Rohrleitungen, Armaturen und Formstücken — Qualifikationsanforderungen an den Umhüller), etc.

7.7.2 Qualification of coating operatives

The applicator shall be responsible for ensuring that the coating operatives are trained and qualified prior to the start of work by:

a) preparing test samples in accordance with the approved APS;

b) evaluating test samples against acceptance criteria;

c) evaluating general competency under criteria described in following text.

Test samples shall be made of pipe or pipeline components that approximate, as closely as practicable, the situations and conditions that will be found during construction, maintenance, or repair.

The purchaser may witness and/or audit any or all aspects of the applicator training and qualification testing process.

The training shall cover the appropriate APS for the applicable coating systems and shall include at least:

a) storage and handling of surface preparation/coating materials and tools;

b) surface cleanliness and surface profile;

c) preheating methods, if required;

d) surface preparation (including adjacent coatings) and coating application procedures;

e) inspection methods;

f) coating repair methods;

g) techniques to mitigate the adverse effect of weather, e.g. temperature, precipitation.

Involvement of the manufacturer in coating application training is recommended.

7.7.2.1 Competency determination

Competency shall be determined by:

a) reviewing the applicator's certificates of coating operative's qualification for appropriateness for the coating system and the version of the APS to be applied;

b) reviewing the applicator's experience logs to determine that the coating operative has

   1) applied the selected coating system using the approved APS, including surface preparation;

   2) applied the selected coating system within the previous year;

c) witnessing the coating operative

   1) applying the selected coating system to the piping in accordance with the APS, including surface preparation;

   2) meeting the acceptance criteria for the selected sample(s).

The purchaser may waive the requirements of c) if the applicator demonstrates that the applicator's certificate of applicator qualification, training and experience are sufficient to ensure competency.

7.7.3 Documentary evidence of applicator's coating operatives' qualification

Upon successful completion of the qualification testing, the applicator and/or coating manufacturer or a training third party shall provide a certificate of operative qualification that states the following:

a) the name of applicator's operatives;

b) the coating system or systems for which the operative is qualified;

c) the APS/PQT used to qualify the operative; and

d) the date of qualification testing.

For traceability, the documentary evidence shall provide a unique identifier for each of the qualified operatives.

7.7.4 Requalification

An applicator's coating operative applying a particular coating system shall be requalified when:

a) there is a technical change in the APS;

b) change in application equipment;

c) there are repeated non-conformances reported on the applied coating;

d) the coating operative has not applied the selected coating system (including surface preparation) for a period of more than one year.

Qualification shall be repeated at least every five years.

The applicator shall ensure that the coating operative is competent to apply the coating system selected for application by maintaining a proper file of the operative's experience. When requested, this file shall be made available to the purchaser.

Consistent with any confidentiality requirements, the following information should be requested:

— the coating operative's name and contact information;

— the application company (applicator) and contact information;

— the project or job number and contact information;

— the application date(s);

— the type of coating system(s) applied (e.g., the product name);

— the APS version number;

— the number of coating applications (e.g. girth welds, repairs); and

— the pipe diameter(s).

7.8 Production testing and inspection

The applicator shall perform inspection and testing during production in accordance with an approved ITP to verify the surface preparation, coating application and the specified properties of the applied FC.

The ITP shall be prepared by the applicator and shall be approved by the purchaser prior to the start of the coating work and prior to the start of any PQT and/or PPT. The ITP shall identify all inspection activities and tests, their frequency, acceptance criteria and the relevant inspection authorities.

Test methods and frequencies are identified in Annex A. Acceptance criteria are given in the relevant clauses to which reference is made in Annex A.

7.8.1 Inspection documents and traceability

The inspection documents shall be in accordance with ISO 10474:2013. The type of certificate of comformance shall be defined in the purchase order.

Field coating reports should identify each inspected pipeline section by a unique identifier and shall record the related material batch number for traceability. Test results shall be linked to the exact locations on which they were performed. Records shall be maintained on a shift and daily basis and shall be available for inspection by the purchaser and/or end user.

The inspection documents signed by the contractor and applicator shall be transmitted to the purchaser at a frequency defined in the purchase order. Cumulative production records shall be maintained daily.

8 Safety requirements

8.1 General

Rehabilitation projects shall consider the operational restrictions and the environmental conditions that determine how the project will be carried out. Environmental conditions include ambient temperatures (affected by wind, humidity, rain, cold, and salinity), soil conditions and access. Operational service restrictions are line flow, line pressure and minimum and maximum temperature ranges.

From a safety perspective, the rehabilitation of live pipelines imposes a number of constraints with the need for careful working practices that may be of lesser importance when working on a non-operational pipeline.

The contractor/supplier shall submit their HSE manual/plan including risk assessment of the foreseen rehabilitation activities for purchaser approval and shall have received approval before the start of field activities. The risk assessment should include considerations for residual pipe wall thickness, pipeline stability and other critical features that will affect the overall risk. The approved procedures for the safe handling, storage and application processes of the selected coating systems, shall be strictly followed.

Before the start of field activities an assessment shall be made of interferences on the pipelines on which activities will be carried out. Especially AC current and DC current interference shall be considered. When necessary, precautionary measures shall be taken before activities commence. Activities shall be stopped when lightning is in progress or imminent.

If the coating materials are classified as hazardous, elementary hazard statement and precautionary measures shall be clearly described on the hazard label according to the national regulations.

SDS for all chemicals and protective coatings to be used within operation areas shall be submitted to purchaser for review and approval for safe handling and disposal. Health and safety precautions shall be clearly described on each chemical container/package.

All waste resulting from removal of existing coating systems and supply and application of new coating systems, shall be contained, collected and properly disposed of in accordance with local Health, Safety and Environmental Protection Standards/Regulations. On request of purchaser this also applies for blasting material.

8.2 Safety precautions in flammable atmosphere

Where there is a risk of flammable atmosphere being present in a particular area, the purchaser may, with the relevant safety authority, impose restrictions on methods of surface preparation based on area classification for plant design and construction/maintenance projects.

The applicator/contractor shall submit to the purchaser for approval, with all necessary data for the proposed coating systems, solvents and coating procedures in order to allow the appropriate precautions to be determined for the duration of coating work.

When required by the relevant safety authority, all equipment used in surface preparation, coating application and inspection, including floodlights or spotlights, shall be compliant with safety requirements, e.g. explosion-proof and spark- proof tools.

Prior to surface preparation all dust/powders shall be removed from the area and properly stored prior to disposal. The flammable atmosphere inside the area shall be monitored periodically. The applicator shall liaise with the purchaser's safety authority for the location to define the monitoring required for flammable atmosphere and the appropriate response in case of alarm.

8.3 Safety precautions in confined space

The procedures for performing safe work in any confined spaces shall be in accordance with purchaser identified HSE regulations. Confined space certification shall be available for all involved operatives.

8.4 Safety precautions for coating removal

If the coating to be removed contains asbestos, coal tar or other materials that require safety precautions, then the relevant national legislation shall be identified before any activity. Encapsulation of old coating material may be requested before removal.

8.5 Safety precautions for surface preparation and coating application

In areas where spark discharge would be hazardous, the abrasive blast nozzle shall be directly bonded to the work metal. This will prevent the build-up of electrostatic charge, which could cause a spark.

Electrical tools shall be in compliance with the area classification.

Operators shall wear goggles, an approved helmet and be connected to a source of clean air. All other persons exposed to the blast dust and chemical fumes shall wear air supplied respirators.

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

The coating manufacturer's recommended instructions regarding VOC release, toxicity and safe handling of all coating materials shall be followed.

8.6 Positive isolation and ventilation

On request of the purchaser and based on HSE requirements, cathodic protection shall be disconnected during the actual surface preparation and coating application works.

In case of fumes or toxic gases ventilation shall be used and any other indication from SDS shall be put in action.

All parts of the work shall be clearly visible.

9 Requirements for quality management and quality assurance

9.1 General

The qualification process shall be carried out according to Clause 7.

The preparation of an APS and related ITP is required and shall be approved by the purchaser.

The approved APS can be validated, if requested, by a PQT, according to an approved ITP.

Before production starts, a PPT shall be performed according to a dedicated ITP. The overall qualification and responsibilities scheme and its application to the several steps of the rehabilitation activities, is represented in Figure 1.

Those parts of the qualification process that are waived by the purchaser, shall be clearly stated and identified in the contract.

During the rehabilitation execution phases an inspection system shall be implemented by the contractor to monitor and execute all the inspection activities reported in the approved ITP for production.

9.2 Test during work execution

Inspection and testing shall be carried out during production in accordance with the agreed ITP. Test procedures and acceptance criteria shall be defined in the ITP. Suggested Testing frequencies are given in Annex A.

Damaged areas created by testing shall be repaired in accordance with Clause 13.

In order to perform the required destructive test, the contractor can also prepare a set of panels or pipe sections according to the dimensions and characteristics approved by the purchaser.

All data collected during inspections and tests shall be recorded in a proper form and be delivered to the purchaser as required in the ITP.

10 Criteria for the condition assessment of an existing coating

10.1 General — Evaluation of coating condition

In the context of this document, coating repair or rehabilitation means undertaking the necessary repairs and improvements, to an existing pipeline, to restore it to an acceptable operational condition for the required operational lifetime.

While for the whole pipeline integrity assessment reference should be made to ISO/FDIS 19345-1 and ISO/FDIS 19345-2, for the determination of the coating condition the following should be considered.

The following overall Program of Work should be performed:

a) Determine the condition of the pipe coating by above ground or in line surveys.

b) Analyse the survey data and select locations for excavation (if foreseen) for direct assessment of coating and any metal loss.

c) Analyse inspection data to determine a rehabilitation program and decide which pipe sections require coating repair or coating rehabilitation and/or cathodic protection improvements and which sections can remain as they are.

d) Select pipeline repair coating(s) and rehabilitation coating(s).

e) Design cathodic protection system improvements.

f) Develop a rehabilitation strategy that prioritizes the remediation works required and schedules the rehabilitation program. The program may extend over many years to provide an acceptable combination of operational safety and long-term requirements. See Annex C.

The coating direct assessment has the aim to verify that the extension and type of coating damage is such as to be considered irreparable, (e.g. widespread and deep cracks, detachments areas, presence of water in the interface substrate/coating, roots, rock or foreign matter intrusion, modification due to the soil characteristics or by chemicals, oil, solvents pollutants, deformations, burned areas, etc.).

10.2 Applicable inspection techniques

The inspection techniques that can be used to assess the condition of an existing coating are those described in ISO 15589-1 and ISO 15589-2 and are summarized below.

They include internal inspection techniques such as in line inspection tools, or above-ground non-intrusive techniques such as direct current voltage gradient surveys (DCVG), alternating current voltage surveys (ACVG) and close-interval potential surveys.

Direct assessment and visual inspections combined with coating evaluation, wall thickness and pit depth measurements at selected bell-holes can also be carried out. Analysis of the results from any of these, or a combination of these surveys can be used to establish suitable remedial measures to extend the pipeline operational lifecycle by coating rehabilitation and/or cathodic protection system remediation.

10.2.1 In Line Inspection (ILI)

Pipeline wall thickness can be determined by an In Line Inspection. A correctly selected tool can identify the extent of any metal loss and whether or not the metal loss is internal or external. In the case of external metal loss, the ILI results can be categorized as general corrosion or local attack, such as pitting.

10.2.2 Direct Current Voltage Gradient Surveys (DCVG)

DCVG surveys are conducted above the pipeline and are able to detect the direction and magnitude of current flowing to a pipeline. This technique enables accurate location of current demands to pipelines. These locations would typically be at coating defects, foreign contacts (e.g. foreign pipelines or earthed systems). The technique can also identify areas of poor electrical resistance of the coating and consequently possible poor coating. The technique does not permit accurate physical sizing of the defects but it is able to quantify in the electrical sense the severity of the defect based on the magnitude and direction of the potential gradient. Best results are obtained at coating defects on an otherwise well coated pipeline. Results on large extents of poorly coated pipeline are not always so definitive. The technique is effective even in areas of d.c. stray current and a.c. interference.

10.2.3 Alternating Current Voltage gradient Survey (ACVG)

ACVG surveys are conducted in a similar manner to the DCVG except the applied signal is at a selected frequency. Foreign contacts and coating defects can also be identified in the same way as the DCVG. Unlike the DCVG, however, ACVG will give no information about the effectiveness of applied cathodic protection. This technique will provide an indication of overall coating quality based on the attenuation of the applied signal. The technique is effective even in areas of d.c. stray current and a.c. interference.

10.2.4 Current density

The current density required to cathodically protect a pipeline increases with time. The design current density and the time related increase in current density is different for each type of coating.

If there is information available concerning the average current density requirements over a period of time greater than or equal to the design life of the pipeline, it is possible to assess the condition of a similarly coated pipeline by comparing the actual current density required with the historical data.

Current density data can also be found in various cathodic protection standards, text books, and coating manufacturer's data sheets.

10.2.5 Direct assessment and visual inspection

Visual inspections provide direct information about the coating condition, remaining wall thickness, pit depths, microbial activity and soil corrosivity. Provided that the visual inspections are carried out at representative locations and the number of visual inspections is statistically significant then the data can be used as a basis for developing rehabilitation programs. If there is sufficient historical information then Bayesian inference statistical analysis can be used to good effect.

Further evaluation of the coating defects is required if it is necessary to prioritize and/or program the excavations and coating repairs.

10.2.6 Exploratory excavations

Some exploratory excavations are essential for the direct assessment and to understand and detail the methods for different aspects of the proposed rehabilitation activities.

Additional observations and measurements should be made at the excavations to provide the basis for determining the rehabilitation requirements and methodology. An example of these measurements and observations is provided in Appendix C.

Each excavation should be accompanied by records detailing all findings to a pre-planned checklist (see Appendix C for an example of a pipeline excavation report), together with photographs of all relevant observations and findings, particularly any damage to the coating and/or the steel pipe surface. The type and nature of any films and calcareous deposits on the steel surface are particularly important as they could be related to the effectiveness of the cathodic protection at individual defects.

Exploratory excavations should be carried out to confirm the scope of work for coating rehabilitation, based upon metal loss surveys, coating and cathodic protection surveys. These exploratory excavations will confirm the defect locations and size/importance of the defects and will allow visual examination of the pipe coating to determine the general condition of the coating (adhesion, degradation type, needs for local repairs) and the mode of coating failure.

10.2.7 Testing of the existing coating system

If deemed necessary for the coating assessment, direct testing of existing coating can be performed. As a minimum, the following coating properties should be checked for conformity with the relevant standards:

— Thickness;

— Adhesion to pipe surface;

— Adhesion of any FC overlap to existing pipe coating;

— Continuity of exposed coating (if feasible by holiday detection);

— Presence of cracks, wrinkles, blisters, water or any other visible damage/defect.

The voltage for holiday detection should be adjusted according to the thickness and type of coating in accordance with the purchaser's recommendations or referring to ISO 21809-3. Holiday detection shall only be carried out on dry coatings and under dry conditions.

Annex C provides guidance on further evaluation techniques.

11 Selection of the rehabilitation coating

11.1 Selection of the pipeline rehabilitation coating system

The selection of suitable pipeline rehabilitation coatings is, from a technical point of view, the major decision to be made for a rehabilitation project. There are a wide variety of coating systems and a wide variety of test methods required to evaluate the performance of a coating.

To specify the requirements of a field applied corrosion protection coating, the long-term performance and potential failure mechanisms under the expected pipeline application and operating conditions shall be taken into account. The use of accelerated test methods are helpful (but not always definitive) in predicting the long-term performance of a coating. Supplementary information from validated field performance of the selected coating can support the results of long term performance laboratory tests.

The fundamental requirement of a coating is that it must form a long-lasting effective barrier against water and oxygen permeation, thereby separating the pipe from its environment and preventing future corrosion.

Coating rehabilitation implies a coating application on site on an existing pipeline. Coating properties to prevent corrosion are the same as any other coating selection. External conditions at the application site that can impact on the success of the coating application should be considered.

For these reasons selection of a rehabilitation coating includes more criteria than a selection for a new pipeline.

A wide variety of test methods are used to evaluate the performance of a coating, e.g. as detailed in ISO 21809-3.

The following criteria should be considered for the selection of the rehabilitation coating:

a) It shall have good long term barrier properties to separate the pipe from the environment, in order to prevent water and oxygen ingress, and to resist mechanical forces such as impact, indentation

and shear. Some parameters influencing initial adhesion are surface cleanliness and surface profile prior to coating application;

b) It must be capable of being applied in the ditch under the prevailing environmental conditions and under operational conditions;

c) it must allow repairs;

d) It needs to have the required (as per applicable PDS) and durable adhesion to the substrate that prevents disbondment and loss of adhesion from the steel surface;

e) the coating and application techniques must be compatible with the existing coatings;

f) It must be resistant to cathodic disbondment, if applicable, within defined limits;

g) It must have appropriate and required long term performance based on chemical and physical characteristics.

The following principal criteria should be considered for the coating selection:

11.1.1 Contamination by soluble salts

Soluble salts present on substrates mainly originate from salts containing chloride. Soluble salts contamination is therefore often designated and measured as chloride contamination. They can have a detrimental effect on the long term coating performance and should therefore be limited, on the substrate and adjacent coating, to a level that does not affect the performance of the new coating. When applicable, the TDS of each individual type of coating should specify maximum allowable concentration of soluble salts or chloride.

Soluble salts contamination checks should reference a specification or guide for testing, such as SSPC Guide 15: Field Methods for Extraction and Analysis of Soluble Salts on Steel and Other Nonporous Substrates. ISO also has a series of tests which are referenced in ISO 8502-2, ISO 8502-5, ISO 8502-6, and ISO 8502-9, outlining the extraction and the measurement of contaminants.

This contamination can be mitigated by washing the substrate according to instructions provided by the APS. Attention should be given to habitat conditions in order to prevent a recurrence of the contamination.

11.1.2 Dust contamination of the substrate

Dust is a type of contamination that can originate from different sources. This includes, but is not limited to, soil, abrasives used for surface cleaning, removed corrosion products, and old coating. They all have in common that they are rather loosely attached to the substrate. Dust can have a number of detrimental effects on the coating performance, e.g. adhesion strength and promote occurrence of coating voids during application . The TDS of each individual type of coating can specify maximum allowable dust concentration.

The reference standard shall be ISO 8502-3 and requirements include both grade and class.

This contamination can be mitigated by cleaning the substrate according to instructions provided by the coating supplier. Attention should be given to habitat conditions in order to prevent a recurrence of the contamination.

11.1.3 Substrate contamination by oil, grease, and other petroleum-like products

Oil, grease and hydrocarbons have in common that they are relatively non-polar compounds being insoluble in water, and that they stick very well to the substrate. They form a film on the substrate that impairs proper adhesion with many types of coating, or impair long term adhesion and proper performance of the coating. The TDS of each individual type of coating can specify maximum allowable concentration of oil, grease, and optionally other petroleum-like products.

Substrate contaminations by oil, grease, or other petroleum-like products can be tested by the black-light test or the water break test, e.g. ASTM F22.

This contamination can be mitigated by washing the substrate with detergents, according to instructions provided by the APS. If the contamination is present and needs to be removed, this can be done by SSPC-SP 1, Solvent Cleaning.

11.1.4 Soil properties and soil stress

Pipeline coatings in buried service are subjected to stresses from the surrounding soil (shear and compressive forces) as a result of the weight of the backfill overburden and the weight of the pipe with its contents. Soil movement such as landslides and settling can occur during pipeline operation. Some types of soil are more prone to movement than others, e.g. clay, sand, rocks, peat. The water content of soil and pipeline movement, due to operating pressure and thermal expansion/contraction, can result in mechanical stress on the pipeline coating. The coating selected shall be compatible with the compressive and shear stresses around a buried pipeline. Special attention will be given to the pipeline outside diameter, wall thickness, burial depth and operating temperature, which may lead to more stringent criteria for shear strength and indentation for the selected coating.

Resistance to the effects of soil stress should be tested by assessing, at least, adhesion, shear stress and indentation strength at room and elevated temperature (if required).

The effect of mechanically aggressive soil conditions can be mitigated by additional mechanical protection or by selecting a suitable backfill.

11.1.5 Additional mechanical protection

Any additional mechanical protection must be compatible with the applied coating without affecting or damaging the coating properties.

11.1.6 Compatibility with existing coating

If the selected coating overlaps the existing coating, it shall be compatible with the existing coating and show proper adhesion to prevent air or water ingress. Where there is a small gap at the interface, the small gap shall be filled with a compatible material.

Compatibility between dissimilar coatings should at least be tested for adhesion and/or cohesive failure at the overlap at room and elevated temperature (if required).

The selected coating must be compatible and ensure the required adhesion, as specified, to the existing coating. Particular attention shall be taken when the parent coating has an irregular surface profile, e.g. coal tar/bitumen applied on site.

11.1.7 Fittings

When fittings are included in the rehabilitation area, the selected coating shall be capable of application on irregular shapes. Some coatings may require filling materials (e.g. mastic/putty) to achieve this and it shall be compatible with the selected coating. The entire system must provide the required properties to prevent corrosion as well as the required mechanical strength.

11.1.8 Feasibility of surface cleaning

The coating shall be compatible with the level of possible surface preparation. The level of possible surface preparation can be influenced by local regulations, environmental concerns, and the work force skills. If it is impossible to remove all traces of the former coating (e.g. primer or paint when sandblasting is not a viable option), the selected coating must be compatible with any pre-existing coating.

11.1.9 Space availability for surface preparation and coating application

The space required to perform the surface preparation and coating application should be taken into consideration when selecting surface preparation method and coating type (e.g. ditch, bell hole or tunnel).

The space around the pipe must be sufficient and strong enough to ensure a safe and proper work area. Engines and equipment requiring access to the pipeline to be rehabilitated may also be a concern for a coating application requiring heavy equipment.

11.1.10 Backfilling time constraints

The coating must be compatible with the backfilling schedule after coating application. If the expected interval between backfilling and coating application is lengthy, the coating must resist (with or without temporary protection) the expected environmental conditions found with exposure above ground, e.g. UV, rain or extreme temperature variations.

11.1.11 Condensation and water/moisture on the substrate

Many types of coating require a dry surface and do not allow water to be present on the substrate. Condensation can appear on the substrate when the substrate temperature is below the dew point of ambient air although it may always not be "visible moisture". Continuous condensation is when the condensation rate is so high that water presence cannot be mitigated, e.g. dripping water. The coating selected must be compatible with application onto moist substrates if continuous condensation is present.

Continuous condensation can be reduced by using a drying system, e.g. absorption, or by reducing (or stopping) the pipeline flow. However, depending on the conditions and dew point, drying systems may not be completely successful on a pipeline with active flow.

Water may also originate from different sources not related to condensation such as from rain or from submersion. Water/moisture can be mitigated by waiting for the surface to dry or by creating a water-tight habitat (when necessary). Raising the substrate temperature is another option but this can often not be achieved on live pipelines.

If the pipeline cannot be isolated from water, the coating shall be capable of application in prevailing conditions and application instructions shall be specified by the manufacturer.

11.1.12 Substrate temperature

Substrate temperature during application shall not exceed the minimum and maximum temperatures as specified in the TDS. This is particularly applicable to live pipelines.

Special attention should be given to substrate temperature and the coating material selected accordingly. High or low temperature can be mitigated by creating a habitat around the pipe.

11.1.13 Product and applied coating temperature

Product temperature during application and applied coating temperature during curing (if any) shall not exceed the minimum and maximum temperatures as specified in the TDS.

Conditioning of the product to mitigate the risk of extreme weather conditions, causing the product temperature to exceed the TDS limits, shall be organized before application. This can be by storage in special containers or other suitable means.

11.1.14 Ambient temperature

Ambient temperature can affect the coating application process, and shall not exceed the minimum and maximum temperature as specified in the TDS.

11.1.15 Relative humidity

Relative humidity can affect the coating application process, and shall not exceed the minimum and maximum humidity as specified in the TDS. In cases when the relative humidity exceeds permissible limits, habitats/tents or other containments should be established to allow the air treatment inside.

11.1.16 Backfill material

If the original soil around the pipe has become contaminated with compounds that will have a negative impact on the long term performance of the rehabilitation coating system (e.g. when hydrocarbon or other chemical leakage or spillage has occurred). It should then be considered to replace the original soil by clean backfill material. The backfill (either original or replacement) shall not contain objects large enough to give rise to unacceptable mechanical forces on the coating (impact, indentation, transversal shear caused by backfill subsidence) that exceed the values specified in the APS.

A coating selection map is reported in Figure 2.

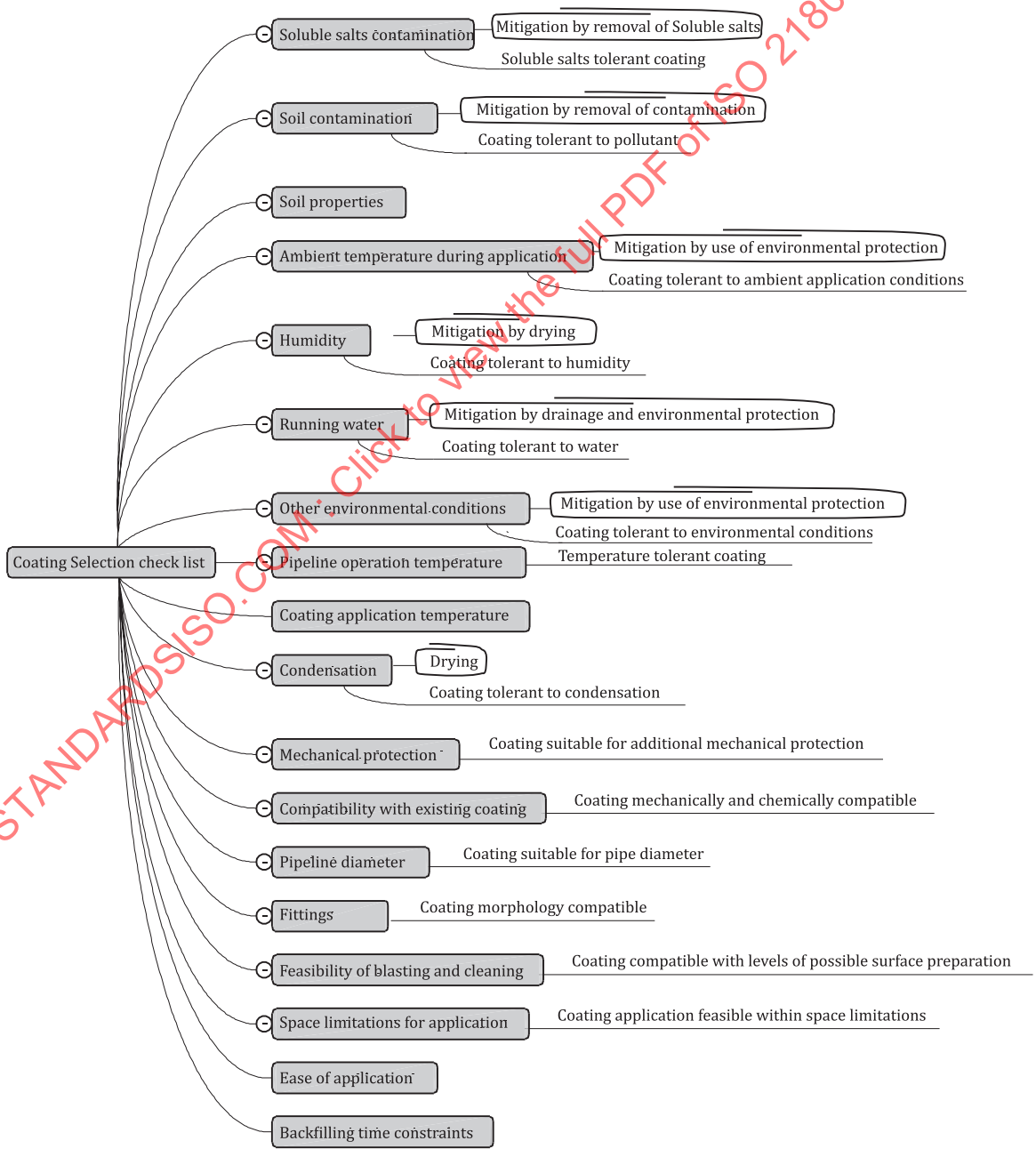


Figure 2 — Coating selection map

11.2 Additional mechanical protection

In certain circumstances the coatings as described in ISO 21809-3 have insufficient resistance to mechanical forces. In such cases it might be considered to apply an additional mechanical protection over the FC.

Examples of suitable additional mechanical protective materials are given below (non-exhaustive):

a) PE, PP or compounds in form of powder, tape, sheet/mesh/woven or nonwoven/fabric, HSS;

b) Elastomeric tape (e.g. vulcanized split wraparound rubber sleeve) or mesh;

c) Epoxy, polyurethane, polyester or vinyl ester with reinforcement by e.g. glass flakes, glass fibres or glass mat. Curing can be natural or be enforced by e.g. heat, UV or water;

d) Epoxy, polyurethane, polyester or vinyl-ester without reinforcement, identical or in modified composition compared to the anti-corrosion layer (e.g. Abrasion Resistant Overlay with FBE);

e) Polyurea;

f) Concrete.

If the selected additional mechanical protection is not in close contact with the coating (e.g. if air or water may be trapped or flow between the coating and the mechanical protection), the additional mechanical protection shall not have any adverse effect on the CP effectiveness as per ISO 15589-1, e.g. cathodic current is prevented to flow to the steel surface exposed to a corrosive electrolyte.

This can be achieved by the use of porous materials or conductive materials.

12 Removal of the existing coating and surface preparation

12.1 General

Each coating system has its own application characteristics and requirements that must be taken into account during the existing coating removal and subsequent surface preparation.

The method of removal can be influenced by HSE and/or environmental restrictions. These restrictions can also influence the method of collection, transport and disposal of removed existing coating.

Irrespective of the material selected for rehabilitation of the external pipeline coating, application requires the same general steps:

a) Expose the pipe;

b) Analysis of the existing coating (when necessary) for any HSE hazard, e.g. by taking and analysing a sample of the existing coating, when the result of the analysis will influence the procedure for the removal of the existing coating;

c) Remove the old coating or leave the old coating intact;

d) Inspect the pipe and make necessary repairs/replacement;

e) Prepare the surface for recoating;

f) Install/apply the Field Coating or the rehabilitation/repair coating.

There are three common practices employed for rehabilitation of pipeline coating:

— Bell hole;

— Out-of-ditch;

— In-the-ditch.

Actual dimensions of the exposed and unexposed support segments depend on pipe diameter, wall thickness, and steel strength. For longer pipe lengths after coating and backfill, the former support pillars are excavated and the newly exposed pipe is cleaned and recoated. For bell holes and in-the-ditch activity, the main determination of exposed length is the ability of the suspended pipe to support itself without buckling. The width and depth of the ditch must be large enough to accommodate the equipment used in each phase of the rehabilitation process, including cleaning and application.

For out-of-the-ditch coating, the pipeline must be taken out of service, cut, and removed from the ground. It is placed on skids and supported above ground to accommodate the rehabilitation process.

12.2 Removal of existing coating

There are several methods for the removal of the existing coating, either manual or automated.

These methods include the use of steam cleaning, chemical cleaning, hand tools, power tools, oscillating tools, automated-on-to-the-pipe machine, induction heating coating removal and abrasive/water blast cleaning and others that may be applicable . Some of them only remove the existing coating and leave the need for a further surface preparation while some also prepare the surface during the coating removal itself.

Removal of existing coating is an important phase of the rehabilitation procedure. The techniques and equipment intended to be used shall ensure that no systematic damages of the metallic surface will occur (e.g. dents, incisions, or other irregularities). The system shall be approved by the purchaser and subject to a specific PQT/PPT.

The effectiveness of manual removal varies from very easy for loose material to nearly impossible for well-bonded coating. The work crew requires suitable protection if there are dangerous substances in the coating materials.

Equipment is available for either hand-operated or automatic coating removal.

12.3 Surface preparation

12.3.1 Hand Tools

Preparing surfaces using hand tools is part of the preparation guidelines of ISO 8501-1 St2 (alternatively SSPC SP 2). Hand tools are generally used when power tools or other types of cleaning equipment cannot be used or not permitted because of specific hazards. Hand tools are also used when the areas to be cleaned are fairly small or otherwise inaccessible.

Hand tool cleaning is designed to remove only loose rust, loose mill scale, loose paint and any other loose contaminants or detrimental foreign matter. It is not intended to remove tight rust, mill scale, paint, etc.

Tools normally used in hand cleaning include wire brushes, scrapers, chisels, chipping hammers, knives, abrasive pads or any non-powered tool that will achieve the desired cleaning quality.

Hand tool cleaning is rather slow and thus expensive because of the manpower required.

It is common that deep marks, burrs, etc. are left on the surface from tool impact and these can interfere with coating performance.

Special surface tolerant coatings are also normally required when using hand tool cleaning.

NOTE ISO 8501-1 St 2 is approximately equivalent to SSPC-SP2 (hand tool cleaning).

12.3.2 Power tools

Often similar to hand tools with the exception of being power driven. Power tools are part of the preparation guidelines ISO 8501-1 St3 (alternatively SSPC SP 3 can be used, see note).

Power tool cleaning is also intended to remove only loose rust, mill scale, paint, etc. and not tightly adhering rust, mill scale, paint, etc.

This is a slow activity because of high equipment wear, high level of operative fatigue and high manpower requirements.

Some of the power tools normally used include chipping and scaling hammers, needle guns, etc., oscillating scrapers, all of which are piston driven. Rotary type tools such as abrasive discs and flap wheels are also used. Power wire brushes are also used but are not recommended as they tend to burnish a surface which limits the adhesion mechanism between a coating and the surfaces.

For activities in hazardous areas all power tools shall be suitably rated for use in the hazardous area.

NOTE ISO 8501-1 St 3 is approximately equivalent to SSPC-SP3 (power tool cleaning).

There is also SSPC-SP11 which is not totally corresponding with ISO 8501-1 St3 due to the requirement for 1 mil (25,4 microns) minimum surface profile.

12.3.3 Abrasive blast cleaning

This method of surface preparation, also known as “sandblasting” or “gritblasting”, is probably the one most used as it is a rapid and proven method.

The end effect of this process is the removal of mill scale, rust paint, old coating and other detrimental contaminants by the eroding action of these abrasive particles to the quality of cleaning specified. Sand/grit blasting equipment is usually portable and available at reasonable costs throughout the world. Two drawbacks, however, are its being limited to outdoor use due to dust and abrasive fallout and its susceptibility to weather changes. Dusting and fallout can be limited somewhat by using “wet blasting” equipment. This type of equipment wets the abrasive flow with water, thereby reducing dusting. Rust inhibitors or surface tolerant coatings are normally required when using this type of equipment.

NOTE

Sa 3 is approximately equivalent to SSPC-SP5 /NACE No. 1 (white metal blast cleaning).

Sa $2\frac{1}{2}$ is approximately equivalent to SSPC-SP10 /NACE No. 2 (near-white metal blast cleaning).

Sa 2 is approximately equivalent to SSPC-SP6/ NACE No. 3 (commercial blast cleaning).

The visual guide reference comparison would include SSPC-VIS 3, ISO 8501-1 and ISO 8501-2. For abrasive blasting it would be VIS 1 or ISO 8501-1 and ISO 8501-2.

12.3.4 Water cleaning/jetting

In most cases, substances that can be removed by hand tool, power tool or abrasive blast cleaning can be removed with a stream of high pressure water. Its rate of cleaning can be faster than hand and power tool, however, it does not always remove tightly adhered coatings. It uses the cheapest abrasive available — water, and is especially useful for maintenance surface preparation due to the lack of sand and grit that may get into equipment. Sand/grit injection units or attachments are available that will assist in the removal of extremely tight coatings and produce surface profiles.

NOTE

SSPC-SP WJ-1/NACE WJ-1 Waterjet Cleaning of Metals — Clean to Bare Substrate

SSPC-SP WJ-2/NACE WJ-2 Waterjet Cleaning of Metals — Very Thorough Cleaning

SSPC-SP WJ-3/NACE WJ-3 Waterjet Cleaning of Metals — Thorough Cleaning

SSPC-SP WJ-4/NACE WJ-4 Waterjet Cleaning of Metals — Light Cleaning

Low pressure water washing — pressures less than 350 bar (5,000 psi)

High pressure water cleaning — pressures of 350 — 700 bar (5,000 to 10,000 psi)

Water jetting — pressures above 700 bar (10,000 psi)

High pressure water jetting — pressures of 700 – 1 700 bar (10,000 to 25,000 psi)

Ultra-high pressure water jetting — pressures greater than 1 700 bar (25,000 psi)

12.3.5 Abrasives

Abrasives, metallic or not metallic, used for the surface preparation shall comply with ISO 11124 or ISO 11126, respectively for metallic and non-metallic abrasives, or with other standards approved by the coating material purchaser.

Compressed air for blast-cleaning shall be free of oil, condensed moisture and any other contaminants, and shall conform to the requirements of ASTM D4285.

Some of the parameters to be considered when choosing an abrasive are:

a) Shape — angular or round;

b) Hardness — hard or soft;

c) Density — high or low;

d) Size — large or small;

e) Type and rust grade of surface to be cleaned;

f) Profile required;

g) Coating system to be used;

h) Degree of cleaning required;

i) Environmental constraints.

Of the above abrasive types, the most commonly used are the cast shot and grit for shop applications, where recycling equipment is in use, and silica and mineral sands or slag abrasives for field applications were recycling of abrasives is impractical.

12.3.6 Surface profile

The definition of surface profile or anchor pattern is a measurement of the roughness of a surface which results from cleaning activity. The profile or anchor pattern is measured from the bottoms of the lowest valley to the tops of the highest peaks and can be expressed as R_{max}, R_y, R_z, R_{y5}.

The depth of profile will be directly related to the size, type and hardness of the abrasive as well as its velocity and angle of impact and the hardness of the surface being cleaned. The minimum and maximum allowable depth (height) will depend on the instructions given by the manufacturer for each specific coating system.

The following references can be used:

a) ISO 8503-4 which is the stylus;

b) ISO 8503-5 which is replica tape as well as the NACE SP0287;

c) ISO 8503-2 which is the comparator method;

d) ASTM D4417 Method B, which is the digital surface profile gauge;

e) ASTM D4417 Method C replica tape;

f) ASTM D4417 Method A comparator;

g) ISO 8501-3 for surface imperfections check.

12.3.7 Rust back (flash rust)

Rust back/flash rust occurs when freshly abrasive blast cleaned steel surfaces are exposed to high humidity, rain or a corrosive atmosphere. The time involved in getting rust back can vary tremendously ranging from minutes to weeks. Under no circumstances should the steel be allowed to rust before re-coating is applied regardless of the time elapsed. It must comply with surface preparation requirements at the time of coating application. One exception to this rule, however, would be the use of surface tolerant coatings, which are designed and tested for application over rusted surfaces.

Abrasive blast cleaning should not be conducted when the surface temperature is less than 3 °C above the dew point. Moisture can condense on the surface if it is colder than the surrounding ambient air temperature and rust back could occur.

12.4 Inspect the pipe after coating removal

An important aspect of the coating-removal process is the ability to see corrosion damage to the pipe. Repairs or replacement of pipe segments must be done prior to coating. For out-of-service lines, sections can be replaced with new pipe.

For in-service "live" pressurized lines, repair is more difficult but can be accomplished using pipe sleeves or other repair methods.

Inspection and testing for coating removal and further surface preparation shall be as required by relevant reference standards and following the approved APS/ITP requirements.

13 Functional requirements for extensive field coating application

13.1 Rehabilitation of in service pipeline

Pipeline coating rehabilitation or in field application in congested or urban areas places greater requirements on the process, the coating material, and the application methods.

The requirements for at least the following shall be taken into account:

a. permits;

b. traffic control plan;

c. night time working;

d. setting of fences, barriers.

After the excavation is opened and the pipe exposed, the pipeline and coating anomalies must be located, the coating removed (or the pipe cut for replacement), the surface cleaned, and the pipe coated. The coating must reach a level of performance, e.g. curing or adhesion or compactness, that prevents damage during backfill.

Coating speed to reach such a performance level, at local environmental conditions, is of critical importance to shorten the time before backfill and final ditch closing.

The interface between the existing coating and the rehabilitation coating should be selected to minimize the risk of corrosion. If the interface is with a poor-quality coating and/or irregular edge, it may not be possible to achieve a perfect interface. In such cases a compromise is required, and if the pipeline is cathodically protected it is recommended that the overlap is restricted to 10 cm. Restricting the overlap to 10 cm will help maintain effective cathodic protection to the existing coating and interface. Larger overlaps can restrict the cathodic protection current flow beneath the overlap. A field coating system for the connection between the existing coating and rehabilitation coating can be chosen to seal the coatings overlap.

In the soil to air transition areas, the coating can be subject to larger mechanical stresses and damage promoting circumstances (e.g. stones, tiles, lawn mowing, direct sun irradiation, UV). This should be considered in the choice of the rehabilitation coating system. See also Clause 15.

The factors and conditions to be considered for the rehabilitation works include, but are not limited to, as follows:

a) definition of rehab needs;

b) definition of the length;

c) coating selection;

d) work planning and logistics;

e) getting permits;

f) environmental concerns/local laws/requirements;

g) defining type of excavation: well/dry point (dewatering);

h) table water level;

i) sheet piling;

j) excavator sizing;

k) water disposal;

l) soil treatment and repositioning;

m) access planning/roads;

n) any civil work;

o) crossing other underground services;

p) waste materials disposal/recycling;

q) presence of land sliding;

r) pipe lifting equipment;

s) specific rehabilitation conditions: cut-backs/coating bevelling;

t) existing coating preparation;

u) overlapping;

v) heat treatment required;

w) free spans and pipe supports;

x) pipeline stability when elevated;

y) pipe movements with respect to curing time;

z) inspection timing;

aa) backfilling (selected soil, first backfill material and backfilling application around the pipe);

bb) local survey (DCVG) after backfilling and within the guarantee time.

The activities to be performed on cased pipeline sections or on casings, should also follow the requirements of ISO 16440.

13.2 Environmental condition

The activities shall be carried out only when the environmental/steel conditions are in compliance with those specified by the manufacturer and/or the project specification for the selected material.

Surface preparation and application shall not be carried out, unless otherwise agreed and reported in the approved APS/ITP, when the steel temperature is less than 3 °C above dew point or when the relative humidity of the air is greater than 80 %.

If the conditions are outside the values recommended by the coating manufacturer (e.g. TDS) and APS/ITP, actions should be taken to bring the environment to the allowed conditions (e.g. stop coating application, air drying, conditioning in confined spaces, surface preheating, coating material preheating, flow reduction).

The temperature of the coating system material shall be within the temperature ranges specified by the manufacturer in the relevant TDS.

13.3 Steel preheat

The equipment used for the pre-heating of pipes shall be approved during the execution of the PQT.

If the contractor uses open flames in direct contact with the pipe surface for pre-heating, the flame shall be kept in motion to guarantee a homogeneous external preheating of the pipe. The flame shall also be adjusted in its combustion ratio so that soot or other combustion products are not deposited on the metal. In this case the flame shall be positioned at a tangent to the surface and never in direct contact with it.

The preheating system and preheating temperature shall neither cause any damage to the adjacent coating nor cause modification to the steel micro structure. Usually the max temperature is limited to 260 °C.

All temperature measurements, performed according to the specific requirements of each type of coating shall be recorded on the production certificate.

13.4 Surface preparation

Surface preparation shall be carried out in accordance with the approved APS.

Prior to the coating application, the surface shall be dry and free of any contamination (such as detritus, dust, non-adhering particles, grease, oil, soluble salts) detrimental to surface preparation or to adhesion of the coating on the steel.

Oil, grease and wax shall be removed by solvent cleaning in accordance with SSPC-SP1.

All visible surface imperfections of the substrate caused by the girth welding operation, such as welding slag and spatter, sharp edges or burrs that could damage the coating, detected before or during surface preparation shall be removed by an approved grinding method or filing techniques according to the approved APS. Grinding of steel defects shall not reduce the wall thickness below the specified minimum wall thickness of the pipe.

Areas of rust or scaling shall be removed by spot abrasive blast-cleaning or wire brushing as specified in the APS.

The cleanliness grade, surface profile, dust level and soluble salts contamination shall be in compliance with the manufacturer's PDS.

The required cleanliness levels shall be verified immediately before the coating application. In case of negative results the surface preparation shall be redone.

If not otherwise required by the APS/ITP, the following general requirements should be considered:

1. surface preparation performed in accordance with the standard ISO 8501-1, grade Sa $2\frac{1}{2}$;
2. profile of abrasive blasted surfaces within 25 and 100 µm (R_z, Ry_5). The profile shall be measured in accordance with the requirements of ISO 8503-4, ISO 8503-5 or NACE SP0287;
3. dust level, measured in accordance with the requirements of ISO 8502-3, shall conform to the maximum dust rating "2" and the maximum dust size class "2".

When the surface preparation is complete, and before application of the coating materials, the amount of water-soluble salts shall meet the specific requirements defined in the approved ITP and should not be more than 50 mg/m^2 (milligrams per square meter). Extraction of contaminants from surface shall be performed in accordance with ISO 8502-6. Quantitative determination of water-soluble salts shall be performed in accordance with ISO 8502-9. The extraction of water soluble salts, after purchaser approval, should be performed using portable equipment.

No surface preparation shall be performed on surfaces that are moist or may become moist before application of the coating.

13.5 Coating application

The coating materials shall be prepared and applied in compliance with the recommendation provided by the coating manufacturer, project specification and in accordance with the approved APS.

13.6 Over the ditch rehabilitation

High-speed over-the-ditch coating operations have different requirements. The key element in this case is the amount of time allowed before the coated pipe must be returned to the support cribbing. For an automated line-travel operation, this means the coating should withstand the pipe weight within the travel speed for such an equipment, or be within the agreed repair rate. Preheating the sections of the pipe that rest on supports prior to coating application accelerates the cure rate and hastens set-down time. The first step in the process is clearing dirt from the pipe. The pipe is then removed from the ditch and cradled on skids. A knife machine can remove the coating and residual dirt. A water-blast machine then removes most of the rest of the debris, leaving only traces of primer behind. The weld-reinforcement area and possible corrosion areas are blasted by hand for inspection.

13.7 Testing and burying the pipe

Care shall be taken when/if the applied coating is not fully cured at time of burial, it must have sufficient strength to withstand the normal stresses of installation, hydrostatic test, backfilling.

In such case it must also possess reaction kinetics that allow completion of cure while underground.

14 Functional requirements for Local Repairs of coating damage

14.1 General

All damage noticed during the inspection or testing of pipes and components, even new during construction, shall be repaired.

Surface preparation and application equipment shall be approved by the purchaser for the specific type of intervention and application, and already validated by a PQT or a PPT.

Relevant documentation on the selection of repair materials, shall be provided to the purchaser for approval.

14.2 Coating damage not exposing bare steel

If the damage is not exposing steel and its depth is within the 20 % of the nominal thickness, no actions are required.

When the damage has a depth down to 80 % of the nominal thickness, a repair should be set to rebuild the nominal thickness of the coating.

When the damage depth is more than 80 %, a repair shall be set to rebuild the anticorrosion properties of the coating as per 14.3.

The repair material shall be suitable to be applied on to the whole damaged area.

The coating around the damaged area shall be feathered and cleaned using sandpaper or rotary disc. The re-cleaning shall be extended, not less than 50 mm, to undamaged surrounding surfaces in order to assure film continuity. The complete specified repair coating system, compatible with the existing coating and suitable to the operational pipe and component conditions, shall be applied on the cleaned area in accordance with the manufacturer's instructions.

Curing conditions and time to inspection must be respected.

14.3 Coating damage exposing bare steel

Where the damage depth is more than 80 % or the steel is exposed to the environment, the damaged areas shall be cleaned by abrasive blasting or power tooling as required by the selected product's TDS/APS/ITP.

The repair material shall be suitable to be applied on to the whole damaged area.

Steel Surface preparation shall be performed as per manufacturer instructions and shall be extended not less than 50 mm to the surrounding sound coating and the edges properly feathered.

If cleaning by abrasive blasting is performed, it shall be in accordance with ISO 8501-1 grade Sa $2\frac{1}{2}$.

Based on the extent of the damage the complete or partial re-coating of the pipe length can be required.

15 Soil-to-air interface

Specific coating products shall be used for soil-to-air interface to prevent:

a) Degradation due to UV exposition;

b) Mechanical damage, caused by objects in the direct vicinity, like stones, tiles etc. or by mechanical impact from e.g. lawn mowing;

c) Thermal influences (hot and frosty);

d) Water/ humidity.

Note that cathodic protection in the transition zone is not effective and visual inspection could be difficult due to construction (e.g. grating, concrete slab).

The coating system or at least the outer wrap shall be UV resistant, water proof and provide mechanical protection.

In the event mill applied pipe coating, like PE or PP, is in the transition zone which is protruding aboveground and is in a good condition, than this pipe coating shall be additionally protected by a mechanical protection coating system which is UV resistant and water proof. In this case the length of the additional protection shall respect the distances given in Figure 3.

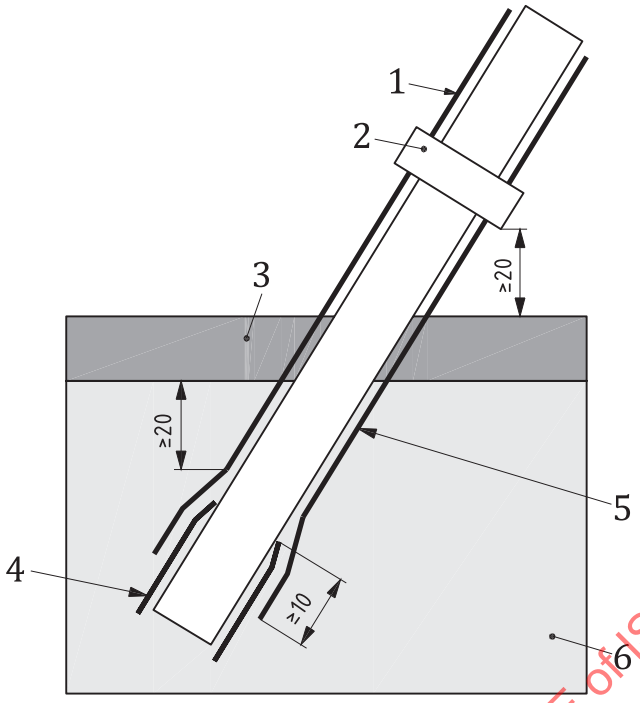
All existing coatings assessed as deteriorated and disbonded from steel, shall be replaced.

Above ground steel pipeline sections are protected against corrosion by a paint coating according to ISO 12944 or other suitable coatings defined by the pipeline owner. The lifetime of the above ground steel pipeline is normally longer than the paint coating applied on the steel and therefore the paint coating is repaired, rehabilitated and/or renewed a number of times during this lifetime. The transition between paint and soil-to-air coating shall be able to match with renewal of the paint coating and there shall be either an overlap of the paint coating over the soil-to-air area or there shall be another suitable means or coating system

15.1 Distances

In Figure 3 the minimum distances are given. Settling of the soil has to be taken into account, such that the minimum distances are maintained in all circumstances.

In underground conditions, in the overlap of soil to air coating over the pipe coating, CP effectiveness shall be taken into account especially when the existing pipe coating is in a suboptimal condition. In such a case the overlap should be limited to the minimum distance of 10 cm.



Key

1 paint
2 overlap configuration depending on coating system
3 e.g. stones
4 pipe coating
5 soil to air coating
6 soil

Figure 3 — Distances

16 Documentation and reporting

At completion of the works the contractor shall produce all documentation and reporting required by this document and ISO 21809-3.

Annex A
(informative)

Test programs for procedure Qualification Trials, Pre-Production Trials or Production Testing

A.1 General

This annex gives the testing frequencies for PQT, PPT and production testing, as defined in this document. The following information is not intended to be used for the preparation for the qualification of a particular material.

Since the main reference standard for coating materials is ISO 21809, reference is made to Annex A of ISO 21809-3. Annex A of this document is harmonized with Annex A of ISO 21809-3:2016.

For materials or material combinations not included in the ISO 21809-3, testing methods and frequencies shall be adapted to those here required by agreement between the parties.

Alternative test regimes and frequencies can be used by agreement.

Requirements for PQT and PPT shall be defined in the purchase order.

A.2 Inspections, tests and frequencies

The inspections that shall be carried out during PQT, PPT and production testing are summarized in Table A.1 (depending on the FC). The list of verifications and test methods together with their frequencies are given in Table A.1.

Some of the requirements for production testing may not be achievable on site. The production test program may therefore be adapted to suit the site conditions based on comparative testing during PQT or PPT.

The test report should contain numerical results when possible.

Any test required that is not mentioned in Table A.1 shall be documented by the manufacturers. This covers long-term tests related to the material itself, such as specific electrical insulation resistance, thermal ageing, or thermal stability.

A shift is defined as the time period when a crew of workers is at work.

A.3 Retest

If one of the tests fails, the test shall be repeated. No further failure is allowed.