



RECOMMENDED PRACTICE
DNV-RP-F102

PIPELINE FIELD JOINT COATING AND
FIELD REPAIR OF LINEPIPE COATING

MAY 2011

DET NORSKE VERITAS

FOREWORD

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CHANGES

- **General**

This issue of the document replaces the October 2010 edition to obtain compliance with ISO 21809-3. As a consequence of this, reference to ASTM, DIN and NF standards for testing of coating properties have largely been replaced by references to testing standards contained or referenced in ISO 21809-3. Some terminology has further been changed for compliance with this (latter) standard.

Incorporation of DNV experience from the use of the preceding 2003 revision have also been included.

- **Main changes May 2011**

- Inclusion of a new section (Sec.5) dedicated to the specification of field joint coating in inquiry and contract for coating work.
- “Coating Data Sheets” have been deleted from the RP and replaced by two new sections (Sec.7 and Sec.8) for FJC/CFR and infill systems, respectively, referring to ISO 21809-3, with some amendments.
- Format for specification of amendments and deviations has been deleted.
- An Inspection and Testing Plan (ITP) format has been added (Annex 1).

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1. General

1.1 Introduction

1.1.1 A primary objective of applying external coatings on submarine pipelines is corrosion control. In addition, coating systems for corrosion control can be designed to provide mechanical protection during installation and operation. A corrosion protective coating may also be combined with a concrete weight coating for anti-buoyancy and/or mechanical protection, or a coating for thermal insulation.

1.1.2 Coatings for external corrosion control of pipelines are applied to individual pipe lengths at a dedicated coating plant. This coating is referred to as “linepipe coating” (sometimes also as “factory coating”, “plant applied coating” or “parent coating”), In order to facilitate girth welding, areas at each end of the individual pipe length are left uncoated. These areas are normally coated after welding by applying a “field joint coating” (FJC) system. The same term applies for coating applied on the welded joint between a pipe and a pipeline component (e.g. a bend or valve body) with pre-fabricated coating. In this document, the term “FJC” is used irrespectively of the coating being applied in a factory or in the “field”.

1.1.3 Depending on the type of linepipe coating, the FJC may consist of one or more layers of coating materials applied for the purpose of corrosion control, mechanical protection and/or thermal insulation. FJC systems may also be designed to provide a smooth transition to a concrete weight coating of the linepipe, or to a thick-layer thermally insulating coating in order to facilitate offshore installation operations. This is typically achieved by application of a moulding compound, referred to in this RP as “infill”. In some cases, pre-fabricated half shells are installed by strapping to the field joint. The infill may further be designed to provide mechanical protection during installation (e.g. against trawl board damage) or thermal insulation.

Guidance note:

For certain FJC systems developed for thermally insulated linepipe coating, the moulding compound serving as an “infill” is considered as an integrated part of the FJC.

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1.1.4 Linepipe coating may suffer damage during handling, transportation or pipeline fabrication/installation, which may require repairs in the field. This is referred to as “coating field repairs” (CFR). As for FJC, CFR systems may consist of one or more layers of coating and may be applied in a factory or in the field. Repair of linepipe coating may also be necessary in the case of deliberate modifications affecting the linepipe coating, e.g. for the purpose of installation of cables for electrical connection between galvanic anodes and pipe material. Certain FJC systems are applicable also for repair of large size damage to linepipe coating. (Repair of linepipe coating performed by the applicator at his premises is not referred to as CFR and is covered in DNV-RP-F106).

Guidance note:

In its widest sense, the term “pipeline coating” includes linepipe coating, field joint coating (FJC), coating field repair (CFR) and infill. Application of FJC, CFR and infill are typically carried out under the same contract either by the installation contractor or by a subcontractor. Linepipe coating on the other hand is mostly carried out by dedicated coating applicator, contracted by either owner, installation contractor or linepipe manufacturer.

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1.1.5 Submarine pipelines are almost invariably designed with a cathodic protection (CP) system, mostly based on galvanic (also called “sacrificial”) anodes. The CP system serves as a back-up for any deficiencies in the pipeline coating, including defects during application and damage during transportation/installation, in addition to any degradation of coating materials and mechanical damage during operation. Hence, CP design for submarine pipelines is closely related to the design and quality control of pipeline coatings, including FJC and CFR (see 1.5.3) For submarine pipelines, maintenance of coating and cathodic protection systems is largely impractical. This is reflected by strict requirements to the quality control of coating application. Submarine pipeline installation by reeling may impose special requirements to both selection of coating type and the quality control of application. Certain linepipe materials (primarily martensitic and duplex ferritic-austenitic stainless steel) may suffer hydrogen induced stress cracking when exposed to CP at high tensile stresses, particularly at welds. For such pipelines, the design and quality control of FJC is critical.

1.2 Scope

1.2.1 This “Recommended Practice” (RP) has been prepared to facilitate both Purchaser’s specification and Applicator’s documentation of quality control for coating work. The RP covers the application of specific types of FJC/CFR and infill systems as referred to below. The use of this RP implies the involvement of Purchaser in quality control aspects, including review of procedures and inspection/testing plans for coating application, witnessing of qualification tests (PQT/PPT) for coating and acceptance of documentation of quality control (Daily Log formats and index for Final Documentation) prior to start of production in order to ensure that the produced coating meets all requirements of this RP and ISO 21809-3.

Guidance note:

For FJC systems, the requirements to design and quality control are in compliance with ISO 21809-3, but with some additions. This means that compliance with this RP ensures full compliance with ISO 21809-3.

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1.2.2 The following 12 types of FJC/CFR systems, applicable to corrosion control of submarine pipelines, and including associated risers, are covered in this document. (The designations used in this RP are the same as in ISO 21809-3 but some amendments are made by introducing a number within parenthesis):

- Type 1D: Cold applied polymeric tape (FJC only)
- Type 2A (1): PE heat shrink sleeve without primer (FJC and CFR)
- Type 2A(2): PP heat shrink sleeve without primer (FJC and CFR)
- Type 2B(1): PE heat shrink sleeve with LE primer (FJC and CFR)
- Type 2C(2): PP heat shrink sleeve with LE primer (FJC and CFR)
- Type 3A: Fusion bonded epoxy (FBE) coating (FJC only)
- Type 2B(2): PE heat shrink sleeve applied on FBE coating (FJC only)
- Type 2C(3): PP heat shrink sleeve applied on FBE coating (FJC only)
- Types 5A, 5B and 5C(1): PP coatings applied on FBE (FJC only)
- Types 5D(1) and 5E: PE coatings applied on FBE (FJC only)
- Type 8A: Polychloroprene coatings (FJC only).

1.2.3 In addition to the FJCs above, this RP also covers the use of PU and PP as infill on pipelines with coating of concrete or relatively thick (> 10 mm) thermal insulation.

Type 4E(1): Moulded PU with primer applied to steel substrate

Type 4E(2): Moulded PU (foamed or solid) applied on top of FJC Type 1D or 2A

Type 4E(3): Moulded PU (foamed or solid) applied on top of an FBE layer (FJC type 3A)

Type 5C(2): Moulded PP applied on top of an FBE layer (FJC type 3A) and an intermediate layer of PP adhesive

Type 5D(2): Moulded PE applied on top of an FBE layer (FJC type 3A) and an intermediate layer of PE adhesive.

Guidance note:

In this RP cast (injected moulded) PP or PU as applied on pipelines with relatively thick thermal insulation is referred to as “infill”. Other infill, typically used on concrete coated pipes, includes asphalt mastic and rapid setting concrete. These types of infill are not covered in this RP.

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1.2.4 This RP may be fully or partly applicable to similar coating and infill systems, or to FJC/CFR associated with onshore pipelines. The user shall then duly consider the needs for amendments and deviations for such applications.

Guidance note:

Some of the coating systems referred to in 1.2.2 and 1.2.3 are also applicable for coating of pipeline components.

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1.2.5 The following activities associated with FJC/CFR are not covered:

- Requirements for the qualification of Manufacturer specific coating materials for general (i.e. not project specific) purposes (see Guidance Note to 6.6.3).
- Detailed design of FJC for project specific purposes (e.g. heat insulation).
- Inspection of linepipe coating during installation and characterisation of damage for subsequent CFR.
- Repair of internal coating and thermally insulating coating.

1.2.6 Considerations related to safety and environmental hazards associated with either coating work or properties and degradation (e.g. leaking of various compounds) of as-applied coating materials (i.e. as reflected by national and multi-national regulations) are beyond the scope of this RP.

1.3 Objectives and use

1.3.1 DNV-RP-F102 has been prepared for compliance with general and coating system specific requirements in ISO 21809-3. This RP focuses on the execution and documentation of quality control, including detailed guidance to the specification of coating work. The requirements to testing and inspection are basically the same as in ISO 21809-3. This RP includes more stringent requirements and detailed recommendations to ensure a consistent quality of the coated pipes and to reduce the effect of ambiguous and incomplete specifications on costs and schedule for submarine pipeline construction (see 1.1.5). Whilst ISO 21809-3 covers FJC for both onshore and offshore pipelines, this RP focuses on FJC for submarine pipelines and includes CFR of linepipe

coating. The RP further covers the application of foamed or solid PU as infill on concrete coated pipes and PP infill on pipes with relatively thick (> 10 mm) thermal insulation.

1.3.2 The cathodic protection design for submarine pipelines in DNV-RP-F103 recognises the importance of (i) design and (ii) quality control of pipeline coatings. To account for this, specific “coating breakdown factors” are defined for linepipe and FJC/CFR coating systems. These factors assume that the quality control of FJC/CFR and infill application is in compliance with this RP and with DNV-RP-F106 for linepipe coating.

1.3.3 This Recommended Practice (RP) may either be used as a guideline for the preparation of Purchaser’s specification for FJC/CFR and infill systems as defined in 1.2.2 and 1.2.3 above, or as an attachment to an inquiry or purchase order for such coating. If Purchaser has chosen to refer to this RP in a purchase document (see definition in Sec. 3), then Applicator shall consider all requirements in this RP as mandatory (see definitions in Sec. 3) unless superseded by amendments and deviations in the specific contract.

Guidance note:

When this RP is used as the governing standard for purchase of linepipe coating, any amendments or revisions should be made with reference to the relevant paragraph of the RP. Requirements that are adequately covered in the RP should not be repeated.

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1.3.4 If reference is made to this RP in a purchase document, the project specific information and requirements given in Sec. 5 shall always be specified by Purchaser.

1.4 Structure of document

1.4.1 Sec. 5 gives requirements and recommendations for Purchaser’s specification of FJC/CFR and infill systems. Requirements to Applicator that apply to all categories of FJC/CFR plus infill are given in Sec. 6, whilst those applicable to a specific system are contained in Sec. 7 and Sec.8 for FJC/CFR and infill, respectively. ANNEX 1 gives an example of an ITP format meeting the requirements in 6.2 of this RP.

1.5 Relation to DNV-OS-F101 and other DNV documents on pipeline corrosion control

1.5.1 DNV-OS-F101 “Submarine Pipeline Systems” Sec. 6 “Design – Materials Engineering” gives some guidelines to the selection and design of pipeline external corrosion protective coatings (including field joint coatings and concrete coatings). DNV-OS-F101 Sec. 8 “Construction – Corrosion Protection and Weight Coating” gives some general requirements to their application.

1.5.2 DNV-RP-F106 “Factory Applied External Pipeline Coatings for External Corrosion Control” gives detailed requirements to the application of external coating referred to as linepipe or factory coating.

1.5.3 Cathodic protection (CP) of coated submarine pipelines is covered in DNV-RP-F103 “Cathodic Protection of Submarine Pipelines by Galvanic Anodes”.

Guidance note:

DNV-RP-F103 offers CP design parameters that assume the requirements to design and quality control of pipeline coatings in DNV-RP-F106 and DNV-RP-F102 (i.e. present RP). Applying these three Recommended Practices together in a project will reduce the need for arbitrary conservatism in CP design due to uncertainties about the performance of the applied coating.

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2. References

The following standards are referred to in this document. The latest editions apply.

2.1 ASTM (American Society for Testing and -Materials)

ASTM D 695 Standard Test Method for Compressive Properties of Rigid Plastics

ASTM D4285 Test Method for Indicating Oil or Water in -Compressed Air

ASTM D4940 Standard Test Method for Conductometric Analysis of Water Soluble Contamination of Blasting Abrasives

2.2 DNV (Det Norske Veritas)

- DNV-OS-F101 Submarine Pipeline Systems
DNV-RP-F106 Factory Applied External Pipeline Coatings for Corrosion Control
DNV-RP-F103 Cathodic Protection of Submarine Pipelines by Galvanic Anodes
DNV-RP-F111 Interference between Trawl Gears and Pipelines

2.3 EN (European Standards)

- EN 10204 Metallic Products – Types of Inspection Documents

2.4 ISO (International Organization for -Standardisation)

- ISO 8501-1 Preparation of Steel Substrates Before Application of Paint 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 Paint 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 – Part 6: Sampling of Soluble Impurities on Surfaces to be Painted – the Bresle Method.
- ISO 8502-9 – Part 9: Field method for conductometric determination of water-soluble salts
- ISO 8503-2 Preparation of Steel Substrates Before Application of Paints and Related Products – Surface Roughness Characteristics of Blast-Cleaned Substrates.
– Part 2: Method for the Grading of Surface Profile of Abrasive Blast-Cleaned Steel – Comparator -Procedure
- ISO 8503-4 – Part 4: Method for the Calibration of ISO Surface Profile Comparators and for the Determination of Surface Profile – Stylus Instrument Procedure
- ISO 8503-5 – Part 5: Replica Tape Method for the Determination of the Surface Profile
- ISO 10474 Steel and Steel Products – Inspection Documents
- ISO 11124 Preparation of Steel Substrates Before Application of Paint and related Products – Specifications for Metallic Blast Cleaning Abrasives
- ISO 11126 Preparation of Steel Substrates Before Application of Paint and related Products – Specifications for Non-Metallic Blast Cleaning Abrasives
- ISO 21809-1 (2011) Petroleum and Natural Gas Industries – External Coatings for Buried or Submerged Pipelines Used in Pipeline Transportation Systems – Part 1: Polyolefin Coatings (3-Layer PE and 3-Layer PP)
- ISO 21809-2 (2007) Petroleum and Natural Gas Industries – External Coatings for Buried or Submerged Pipelines Used in Pipeline Transportation Systems – Part 2: Fusion-bonded Epoxy Coatings

3. Terminology and Definitions

<i>Owner</i>	party legally responsible for design, construction and operation of the pipeline
<i>Purchaser</i>	party (Owner or main contractor acting on Owner’s behalf) issuing inquiry or contract for coating work, or a nominated representative.
<i>coating</i>	“coating”, “coating application” and “coating -material” may refer to an “infill” as well as to FJC / CFR.
<i>Applicator</i>	party to whom the coating work has been contracted.
<i>Manufacturer</i>	manufacturer of coating “raw” materials purchased by Applicator.
<i>shall</i>	indicates a mandatory requirement.
<i>should</i>	indicates a preferred course of action (recommendation).
<i>may</i>	indicates a permissible course of action (option).
<i>agreed agreement</i>	refers to a written arrangement between <i>Purchaser</i> and <i>Applicator</i> (e.g. as stated in a contract)
<i>report and notify</i>	refers to an action by <i>Applicator</i> in writing.

<i>accepted</i>	refers to a confirmation by <i>Purchaser</i> in writing.
<i>acceptance</i>	
<i>certificate</i>	refers to the confirmation of specified properties issued by <i>Applicator</i> or <i>Manufacturer</i>
<i>certified</i>	according to ISO 10474: 3.1B or equivalent (e.g. EN 10204; 3.1).
<i>purchase</i>	refers to an inquiry/tender, or purchase/contract specification, as relevant
<i>document(s)</i>	

For definition of coating terms associated with submarine pipeline systems, reference is made to 1.1 above.

4. Abbreviations

APS	Application Procedure Specification (see 6.1)
CDS	Coating Data Sheet
CFR	Coating Field Repair
CP	Cathodic Protection
CR	Concession Request
FBE	Fusion Bonded Epoxy
FJ	Field Joint
FJC	Field Joint Coating
ITP	Inspection and Testing Plan (see 6.2)
LE	Liquid Epoxy
MDS	Material Data Sheet (see 6.6.4)
MS	Manufacturer Specification
NC	Non-Conformity
PE	Polyethylene (polyethene)
PP	Polypropylene (polypropene)
PPT	Pre-Production Trial (see 6.4)
PQT	Procedure Qualification Trial (see 6.4)
PU	Polyurethane
PVC	Polyvinylchloride
RP	Recommended Practice
3LPE	3-Layer Polyethylene Coating
3LPP	3-Layer Polypropylene Coating

5. Specification of FJC and CFR

5.1 General

5.1.1 This section contains requirements and guidance to Purchaser's specification of FJC/CFR in order to clearly describe the design and quality control needed for a specific project and to avoid delays in production schedule.

5.1.2 If reference is made to this RP in a purchase document (see definition in Sec. 3), the following additional information (5.2) and requirements (5.3 and 5.4) shall always be specified, if applicable and relevant to the specific FJC/CFR and infill system as defined in Sec.7 and 8, respectively. (5.4 is intended as a check list for optional requirements).

5.2 Information to Applicator

5.2.1 The following information shall be provided in an inquiry, as relevant for the actual project:

- Pipe material (reference to selected standard/grade or purchaser's specification).
- Pipe dimensions, including nominal inner diameter, wall thickness and length (with tolerances).
- Longitudinal seam weld and girth weld dimensions, including tolerances, if considered relevant for the specified FJC system.
- Purchaser specification for linepipe (and pipeline components, if applicable)
- Linepipe coating specification
- Any long term storage of pipe joints at Applicator's premises requiring special protection (e.g. UV protection)

- Number of FJC to be applied for each pipe material grade and dimension.
- Linepipe coating factory cut back dimensions, including tolerances. Any temporary corrosion protective coating applied on cut backs or internal pipe coating.
- Pipeline maximum and minimum operating temperature, design life and any other project design premises and other information considered relevant to the detailed design of FJC/CFR and infill (e.g. lay method including roller and stinger configuration, installation temperature if cold climate area).
- Any time constraints and/or space constraints (e.g. equipment size) for application during production.
- Any special requirements to cooling/curing of FJC or infill for compatibility with downstream installation equipment (6.4.12).

5.3 Mandatory requirements to be specified by Purchaser

5.3.1 The following requirements to the design and quality of FJC (including any infill) shall always be specified by Purchaser:

- Project specific requirements associated with the detailed design of FJC/CFR and infill systems; e.g. configuration of multi-layer systems, overlap to parent coating, minimum thickness of individual layers, thermal insulation capacity, composition and mechanical or physical properties of any “infill”, colour of coating
- Project specific requirements to “Procedure Qualification Trial” (PQT) and “Pre-Production Trial” (PPT), see 6.4, including schedule for notification and reporting, number of FJC/CFR for testing and any special requirements for testing (e.g. full scale bend or impact testing of infill).
- Permissible repairs for FJC, and infill if applicable (see 6.11).
- Requirements for pipe tracking and marking, if applicable (see 6.12).
- Requirements for documentation, e.g. schedule for supply of documentation and documentation format (see 6.14).

5.3.2 If inspection and repair of linepipe coating damage (CFR) on pipe joints as received by Applicator is included in the scope of work (see 6.7.1), the following requirements shall also be enclosed:

- Requirements for inspection for linepipe coating damage; e.g. type/method, extent/frequency and acceptance criteria.
- Acceptance criteria for linepipe coating repair; e.g. maximum size and number of specific types of defects per pipe for damage considered repairable.
- Any special requirements to repair techniques and materials.

5.4 Optional requirements for specification by Purchaser

5.4.1 The following items, intended as a check-list, may be included in purchase documents, as applicable and relevant.

- Additional testing and any special conditions for testing (e.g. full scale bend testing and testing above or below normal ambient temperature).
- Requirements to Applicator’s quality system (e.g. certification to ISO 9000).
- Requirements to repairs of linepipe coating after connection of anodes (see 6.4.9).
- Requirements to the verification of no harmful effects of FJC on the linepipe coating (see 6.4.11).
- Specific coating materials to be used (e.g. Manufacturer specific systems/grades, see 6.6.3).
- Specific requirements for automatic control and recording of application parameters, e.g. during FBE application (see 6.9.6).
- Specific requirements to the ITP (6.2.3).
- Facilities needed for Purchaser’s quality surveillance.
- Regulatory or Purchaser’s requirements for control of health and environmental hazards associated with coating work (1.2.6).
- Applicator’s management of non-conformities and concession requests (6.1.3).
- Requirements for full scale impact and bending test for PQT/PPT of infill (8.2-8.4).
- Requirements to approval of procedures other than those indicated for mandatory acceptance in 6.1.2.
- Special requirements to handling, storage and transportation of coated pipes, if relevant (see 6.13).
- Special requirements to content, format and storage medium of final documentation (6.14.4).
- Deviations from or amendments to this RP.

6. Common Requirements

6.1 Application Procedure Specification (APS)

6.1.1 All work associated with the application of FJC/CFR and any infill (including the qualification of coating by a “PQT” and/or “PPT”, see 6.4) shall be described in procedures which shall be compiled in an “Application Procedure Specification” (APS). This APS shall be submitted to Purchaser prior to the PQT, PPT and/or start

of production. A schedule for supply of the APS should be specified in purchase documents.

6.1.2 The APS shall as a minimum include the following data sheets, drawings, procedures and other information:

- drawings or sketches showing detailed design of FJC, defining e.g. parent coating overlap, length and chamfer angle of parent coating cut-back, thickness of individual layers, calculations of heat insulation, design of permanent moulds or straps for infill, as applicable
- material data sheets (MDS) for coating and blasting materials, including any permanent strapping (6.6.4)
- procedure for incoming control, handling and storage of materials for surface preparation and coating (6.6.10-6.6.13)
- procedure for preparation of steel surface and parent coating cutback (6.8)
- procedure for coating application (including control and recording of essential process parameters, see 6.9)
- procedures for inspection and testing (6.7-6.10)
- procedure for repair of unacceptable coating (FJC/CFR and infill, as applicable, see 6.11)
- procedure for stripping of rejected FJC (and infill, if applicable), see 6.11
- procedure for handling, storage and transportation of coated pipes (if included in scope of work, see 6.13)
- procedure for documentation, traceability and marking of FJC (if applicable, see 6.12).

Drawings (first item) and procedures for last four items are always subject to acceptance by Purchaser and shall be issued as separate project specific documents. Other items which are not project specific and do not require acceptance by Purchaser may be compiled in one document.

Guidance note:

For “accepted”/ “acceptance” and “agreed” /”agreement”, see definitions in Sec.3.

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6.1.3 Purchaser may require in purchase documents that additional information shall be included in the APS, e.g. QA/QC responsibilities, management of non-conformances and concession requests (see 5.4).

6.2 Inspection and Testing Plan (ITP)

6.2.1 All work associated with coating application (including its qualification by a “PQT”/“PPT”, see 6.4), shall be compiled in a project specific “Inspection and Test Plan” (ITP), sometimes referred to as “quality inspection plan” or “quality plan” or “quality control plan”. The ITP shall be in tabular form and shall be issued as a separate project document (i.e. not included in the APS). An ITP for PQT/PPT shall cover all the qualification activities and shall be issued to Purchaser in due time prior to the PQT/PPT. The ITP shall also contain all activities relevant for PQT/PPT and production. Following a successful completion of the PQT/PPT, Applicator shall issue a new ITP dedicated for production (i.e. by removing the qualification specific activities from the first ITP).

6.2.2 The ITP shall be submitted to Purchaser for acceptance in a timely manner (as per purchase documents) prior to PQT/PPT and start of production, respectively. Purchaser shall identify any hold and witness points in the ITP and inform Applicator accordingly.

6.2.3 The ITP shall contain all activities with any relevance to quality control, including incoming control of coating materials, inspection and marking of incoming pipe (if applicable to the scope), surface preparation, coating application (including monitoring and recording of essential process parameters, if applicable), inspection/testing, repairs and marking of the applied FJC (if applicable). Each activity shall be assigned a unique number and shall be listed in consecutive order. For each activity the following shall be specified:

- reference to the applicable clause/paragraph of the purchase specification
- reference to the applicable standard, procedure or equipment to be used (e.g. contact thermometer) if a procedure/standard is not required
- frequency/extent of testing and inspection
- recording of essential process parameters (if applicable)
- acceptance criterion/criteria and any special conditions for testing (e.g. temperature, duration, environment)
- reporting document
- inspection code (e.g. inspection, witnessing and hold points) for the parties to be involved. Applicator’s involvement of QA/QC personnel and operators shall be indicated in the ITP.

6.2.4 The ITP shall contain a list of references to all relevant project documents issued by Purchaser and Applicator.

6.2.5 For compliance with this RP, test methods and acceptance criteria in the ITP shall be in accordance with ISO 21809-3. Use of alternative test methods (e.g. ASTM) requires Purchaser’s agreement.

6.2.6 ANNEX 1 gives an example of an ITP format meeting the requirements above.

6.3 Daily Log

6.3.1 All data from inspection and testing of FJC/CFR, essential operating parameters (if applicable) and calibration of testing and monitoring equipment, shall be noted in a “Daily Log” (also referred to as “Daily Report”). Repairs and rejections of applied FJC/CFR shall also be noted in the Daily Log.

6.3.2 For FJC/CFR specific inspection and testing data, reference shall be made to unique pipe numbers or joint number (see 6.12). This may be the pipe number defined by linepipe manufacturer, or a consecutive installation number for pipes/joints determined by the installation contractor. The Daily Log shall further ensure traceability of FJC/CFR to individual coating material batches/lots, as defined by material certificates from the Manufacturers.

6.3.3 The Daily Log shall contain the actual physical/mechanical parameters being recorded (not to be replaced by e.g. “passed” only). The Daily Log shall be updated on a daily basis and shall be available for Purchaser’s review at any time during coating application.

6.3.4 A “Daily Log” format shall be accepted by Purchaser prior to start of production and a draft format shall be submitted prior to the PQT/PPT unless waived by Purchaser. Daily Logs covering all FJC/CFR shall be included in the final documentation (see 6.14.4).

6.4 Procedure Qualification Trial (PQT) and Pre-Production Trial (PPT)

6.4.1 For compliance with this RP, a project specific “procedure qualification trial” (PQT, also referred to as a “procedure qualification test”) and Pre-Production Trial (also referred to as a “Pre-Production Test”) are mandatory. The primary objective of the PQT/PPT is to verify that the APS and ITP are adequate to achieve the specified as-applied coating properties. A PQT is to be performed at the premises of Applicator (or any other agreed location) whilst the PPT is to be performed at the actual site of application (e.g. a laying barge for installation of submarine pipelines) using the personnel mobilised for coating work in the field in order to have them individually qualified and to take into account the environmental and other site specific effects on the coating application. Use of personnel during production that have not been individually qualified shall be accepted by Purchaser. For FJC/CFR and infill applied in a factory as used for coating of pipeline sections (“stalks”) to be installed by reeling, it is not required to carry out any PPT in addition to the PQT since the location of the coating is the same and coating applicators can be qualified at the PQT.

Guidance note:

Applicator should duly consider the needs to carry out internal tests prior to the execution of the PQT.

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6.4.2 FJC/CFR and infill procedures and equipment for coating shall be qualified prior to production through the execution of a PQT. For FJC/CFR and infill to be carried out in the field, a PPT shall further be performed in representative/realistic field conditions. The PQT shall be scheduled taking into account the time needed to complete and report the testing.

Guidance note:

The verification of coating properties by destructive testing, as conducted during regular production of linepipe coating (e.g. by peel testing at pipe ends) is not feasible, or at least cumbersome for FJC. The qualification of an APS and ITP for FJC/CFR and infill is consequently regarded as crucial. Moreover, the quality of the applied coating is more dependent on coating applicator skills. It is therefore recommended that the requirement to a PQT/PPT in this document is not waived and that the PQT/PPT is witnessed by a competent person representing Purchaser.

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6.4.3 Specific requirements for PQT/PPT, including schedule for notification and reporting, and any preparations of FJC/CFR additional to the minimum requirements in 6.4.7, should be specified in purchase documents (see 5.3.1 and definition of “purchase documents” in Sec. 3).

6.4.4 An APS and ITP specific for the PQT (and PPT if applicable) shall be submitted to Purchaser in a timely manner (as per purchase document) prior to start-up of the qualification activities. Applicator shall further submit a PQT/PPT schedule referring to the individual pipes to be coated and the testing to be performed on each of these pipes. Furthermore, a PQT/PPT reporting index/format shall be submitted.

6.4.5 Coating application temperature, drying or curing conditions as specified in the APS/ITP shall be according to Manufacturer’s recommendations and any additional requirements in Sec. 7 or Sec. 8. Calibration certificates for instruments essential to quality control (e.g. temperature sensors, thickness gauges) shall be available for Purchaser’s review during the PQT/PPT.

6.4.6 Coated pipes of the same supply as to be used for installation shall be utilised for the PQT/PPT. Purchaser shall supply pipes for the PQT and any internal trials as requested by Applicator to meet the PQT schedule (preferably to be agreed in purchase document). The pipes shall be prepared (by Applicator unless otherwise agreed) to simulate the cut-back of the linepipe (including any concrete or thermally insulating coating) and a simulated girth weld shall be applied.

Guidance note:

For infill systems susceptible to cracking during reel installation, mismatch in wall thickness and relative strength of weld and base materials may affect cracking initiation. The same applies to the effect of factory prepared cut backs of the linepipe coating. Purchaser should therefore consider to include testing of pipes with an actual girth weld for any full scale bend testing.

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6.4.7 As a minimum, three (simulated) FJs shall be coated with a full coating system. For 3LPE/3LPP FJC systems with an innermost layer of FBE, minimum one joint each shall be coated with FBE only and with FBE plus adhesive for verification of FBE thickness, curing and adhesion of FBE and adhesive thickness, respectively. For qualification of CFRs, minimum 3 repairs shall be performed (for each repair procedure) using the maximum allowable repair size. The duration of the individual main activities (e.g. blast cleaning, coating application) shall be roughly the same as to be used during production, and shall be reported.

FJCs associated with joining of pipes or pipeline components with different coating systems shall be subject to a specific PQT/PPT.

6.4.8 Qualification of CFRs shall be performed to verify the properties of maximum allowable repair size as specified in purchase documents. Unless otherwise agreed, three repairs shall be carried out for each repair procedure to be used for production. Testing shall as a minimum include holiday detection and adhesion to steel surface and/or parent coating. It shall further be demonstrated that the repair does not deteriorate the properties of the adjacent parent coating (e.g. adhesion to steel substrate).

Guidance note:

Testing of adhesion shall be performed according to an agreed method to demonstrate “cohesive failure” (i.e. no adhesive failure of repair to steel substrate or repair to parent coating).

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6.4.9 For FJC or CFR to cover welded or brazed connections of galvanic anodes or other items, testing methods and acceptance criteria for verification of relevant properties shall be agreed based on e.g. Purchaser’s tentative specification in inquiry, or Applicator’s proposal.

Guidance note:

Testing methods and acceptance criteria will be dependent on the detailed design that may not be completed at the issue of inquiry.

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6.4.10 Inspection and testing of FJC/CFR applied for PQT/PPT shall be performed as specified in Sec. 6 in ISO 21809-3 (2008) and any amendments of the purchase documents (see 5.3 and 5.4). In addition, requirements in Sec. 7 or 8 in this RP shall apply.

6.4.11 The PQT shall demonstrate that the materials and application procedure used for FJC/CFR and any infill do not deteriorate the properties of the adjacent linepipe coating (e.g. mechanical properties and adhesion to steel substrate) or any internal pipe coating. Testing methods and acceptance criteria for verification of relevant properties shall be agreed based on Purchaser’s specification in inquiry or Applicator’s quotation.

Guidance note:

Testing methods and acceptance criteria will be dependent on the detailed design that may not be completed at the time of inquiry issue. For the linepipe coating, the verification may include e.g. testing of resistance to peeling and cathodic disbonding. Verification of no detrimental effects on any internal coating shall include e.g. visual examination for discolouration, cracking or blistering and adhesion test. Preferably the PQT for linepipe coating shall include testing of the effect of any heating required for FJC application.

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6.4.12 It shall be demonstrated during the PQT that the applied FJC (including any infill) can be efficiently cooled (or cured, if applicable) within the period of time required to avoid damage by downstream rollers or other equipment. (Purchaser to specify conditions and requirements, see 5.2.1)

6.4.13 For pipelines to be installed by reeling, Purchaser should duly consider a full scale bending test to verify FJC adhesion to parent coating and general flexibility of a FJC/infill assembly for inclusion in the PQT; especially for pipes with thermally insulating coating. Testing may include e.g. visual examination of evidence for cracking or disbonding of innermost layer or between individual layers and testing of residual adhesion strength. For FJC/infill of pipes with concrete coating, the need for a full scale impact test (simulating trawl board impact) should also be considered. (Any full scale testing shall be specified in purchase documents, see 5.4.1).

6.4.14 A procedure for stripping of rejected FJC and infill, and repair of imperfect coating work, shall be qualified during the PQT and/or PPT (see 6.11)

6.4.15 Results from all inspection and testing, recordings of essential process parameters for coating (if applicable), coating material certificates, calibration certificates and relevant MDSs shall be compiled in a PQT/PPT report. The report shall contain the actually measured values during testing (measurements of e.g. temperature and thickness shall not be indicated as “passed”/“failed” only). Place, date and names of Purchaser’s attendees shall be contained in the report. Unless otherwise agreed, the PQT report shall be accepted by Purchaser prior to any PPT and start of production. The PPT report shall identify FJC/CFR applicators (i.e. the personnel) qualified for production.

Guidance note:

Cathodic disbondment tests last normally 28 days, so that it may not always be practical to await the completion of the test prior to start of production.

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6.5 Quality control of production

6.5.1 Prior to start-up of regular production, Applicator shall submit the following documents to Purchaser for acceptance:

- an APS in accordance with 6.1, amended/revised based on results from the PQT/PPT as needed
- a project specific ITP in accordance with 6.2, updated based on the results from the PQT/PPT
- a Daily Log Format, amended/revised based on results from the PQT as needed.

6.5.2 The APS, ITP, and Daily Log shall be in English unless otherwise agreed.

6.5.3 Unless otherwise agreed, methods and frequency of inspection and testing, as well as acceptance criteria shall be in accordance with Sec. 8 in ISO 21809-3 (2011).

6.5.4 Standards, procedures and work instructions referenced in the ITP, shall be available to all persons concerned with the associated work and in a language of which they have a working knowledge.

6.5.5 Purchaser shall have the right to inspect and monitor any activity associated with coating work throughout production and to carry out audits of Applicator’s QA/QC system.

6.6 Coating and blasting materials

6.6.1 In this sub-section, the term “coating materials” may refer to materials associated with FJC, CFR and/or infill.

6.6.2 The selection of coating materials for a particular project, and the specification of properties to be verified during PQT/PPT and production, shall take into account the maximum and minimum operating temperature of the pipeline, and any special conditions during installation and operation.

Guidance note:

Unless included in Applicator’s scope of work, the selection of generic types of coating materials (e.g. high density PE or PP) shall be specified by Purchaser. (This selection is typically carried out during conceptual design).

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6.6.3 Manufacturer specific coating materials shall be specified by Applicator in the APS. Purchaser may specify in inquiry any preferences for Manufacturer specific coating materials.

Guidance note:

Prior to the issue of a specific purchase order, Purchaser or Applicator may choose to qualify specific coating materials according to their own requirements for FJC/CFR and infill (which need not be project specific). Such coating qualification should be specific to a manufacturing facility, and a defined range of manufacturing process parameters.

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6.6.4 Coating materials shall be described in Manufacturer specific “Material Data Sheets” (MDS), including relevant properties of raw materials and processed (as-applied) materials, recommendations for surface preparation, application temperature range, conditions for curing/ drying, detailed instruction for storage and handling. The MDSs shall be included in the APS. Certain properties may be specified in the MDS as “typical” values and are as such not applicable as acceptance criteria for batch wise testing. In the CDSs, reference is therefore made to Manufacturer’s Specification (MS) as a max/min value guaranteed by Manufacturer and specified in e.g. batch certificates (ISO 10474 Type 3.1.B or equivalent).

6.6.5 Testing and certification of coating material properties may relate to properties of either raw materials (as-delivered) or processed (as-applied) materials. In the latter case, test panels with applied coating, or

specially prepared coating layers (i.e. without substrate) are used. The testing is normally performed by Manufacturer.

6.6.6 Certain properties related to raw materials (as-delivered) for coating shall be reported per batch or lot (i.e. by an “inspection certificate” type 3.1.B according to ISO 10474 or equivalent), as specified for specific types of FJC/CFR and infill systems in Sec. 7 and Sec. 8, respectively.

Guidance note:

In the case of continuous production, “batches” will not apply and a “lot” is defined based on hours, weight and/or volume of production.

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6.6.7 Applicator shall verify that all coating materials and abrasives received are in accordance with the specified requirements in the APS/ITP by review of batch certificates. Review of certificates and any verification testing to be performed by Applicator shall be included as separate items in the ITP.

6.6.8 For properties of processed (as-applied) coating materials, and in particular those related to long-term environmental degradation resistance, data for a representative product specification (i.e. not batch or lot specific) will normally apply and a “test report” based on non-specific testing is issued by Manufacturer (ISO 10474 type 2.2 or equivalent) For certain types of FJC/CFR and infill systems, mandatory requirements for certification of such properties apply as specified in Sec. 7 and Sec. 8, respectively. Test reports covering as-applied properties shall then be included in the PQT report.

6.6.9 Properties of blasting materials shall comply with ISO 11124 and ISO 11126 for carbon-steel and stainless steel linepipe materials, respectively, and shall be documented in MDSs for inclusion in the APS. For stainless steel linepipe, stainless steel grit (not covered by ISO 11126) is also applicable.

6.6.10 Until compliance with specified requirements has been confirmed, the coating and blasting materials received by Applicator shall be kept physically separated from accepted materials. Any materials checked and found non-conforming shall be clearly marked and quarantined.

6.6.11 All materials to be used for surface preparation and coating shall be contained in their original packing until use and shall be adequately marked, including:

- manufacturer’s name and location of manufacture
- material type and product designation
- batch/lot number
- weight (for materials in drums, bags or similar)
- size (for materials in rolls or similar)
- date of manufacturing (and shelf life, if applicable)
- manufacturing standard (if applicable)
- short instruction for storage (including max/min temperature) and handling (including health and safety notes).

6.6.12 Applicator shall ensure that all materials for coating and surface preparation are stored and handled such that any damage or deterioration is avoided (e.g. by the environment or other effects). Manufacturer’s recommendations for storage and use shall be readily available for Purchaser’s review.

6.6.13 All completed FJC/CFR and infill shall be traceable to individual batches or lots of coating materials. Coating materials shall not be recycled.

6.7 Inspection of linepipe coating for CFR and of FJs prior to coating

6.7.1 Inspection of linepipe coating (if included in the scope of work) and assessment of coating damage for CFR shall be carried out as specified by Purchaser (see 5.3.2). Such inspection may include visual examination and/or “holiday” detection (manual or automatic). A detailed procedure shall then be included in the APS (see 6.1) and frequency and extent of inspection shall be included in the ITP (see 6.2).

Guidance note:

Characterisation of damage to the linepipe coating shall distinguish between

- a) superficial defects that can be repaired by light surface dressing
- b) defects with major reduction in coating thickness but without exposure of bare metal (or no indication by “holiday” detector)
- c) damage that extends down to the pipe material or an inner coating layer (indication by holiday detector).

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6.7.2 Dimensions of parent coating cutback, chamfer geometry and general conditions of the parent coating in the overlap area shall be inspected as deemed necessary to confirm suitability for the specific FJC/CFR system. Applicator shall promptly inform Purchaser of any defects deemed to adversely affect the properties of FJC/CFR.

6.7.3 The girth weld and adjacent steel surface to be coated shall be subject to an initial visual examination. Any visual signs of organic contaminants like oil and grease shall be removed by using suitable solvents or detergents (type to be specified in APS). Dirt or salts shall be removed by high pressure washing with fresh water. Any dents, laps, weld sputter or other surface defects that could deteriorate the properties of the coating shall be eliminated by light (“cosmetic”) grinding only. Purchaser shall be promptly informed if any defects cannot be removed by such measures.

Guidance note:

Cleaning of pipe ends from dirt and salts should be carried out by the welding contractor prior to welding. Removal of weld sputter and any other surface contaminants associated with the welding process should also be included in welding contractor’s scope of work. However, Applicator shall confirm that the surface is suitable for FJC and carry out corrective measures if required. In case the properties of the weld cannot be rectified by suitable measures and are deemed to affect the properties of the FJC detrimentally, Purchaser (or other party responsible for welding) shall be promptly informed.

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6.8 Preparation of steel surface and linepipe coating for application of FJC/CFR

6.8.1 This sub-section covers and amends the requirements in ISO 21809-3 (2008), sub-section 9.1.

6.8.2 All surface preparation and associated inspection and monitoring activities shall be carried out according to the qualified APS and ITP. Methods, acceptance criteria and frequency and/or extent of inspection and testing shall comply with requirements given for specific types of FJC/CFR (Sec. 7) and infill (Sec. 8) and any amendments in purchase documents (see 5.4).

6.8.3 Prior to surface preparation by blast cleaning, parent coating shall be shielded if required to avoid any detrimental effects of this work.

6.8.4 Pipe surfaces shall be prepared for coating using blast cleaning or brushing to provide a surface cleanliness and surface roughness (“anchor pattern”) to meet the requirements for the applicable FJC/CFR (Sec. 7) and infill system (Sec. 8). Any relaxation of these requirements based on Manufacturer’s recommendations shall be accepted by Purchaser. Materials and equipment to be used shall be described in the APS and frequency and extent of inspection shall be included in the ITP. Once qualified, any changes from the APS/ITP shall be formally accepted by Purchaser through a “concession request” (CR).

6.8.5 Relevant properties of blasting materials shall be specified in a MDS (see 6.6.4). Receipt, storage and marking of purchased materials shall be as defined in 6.6.7-6.6.13. The blasting material and pressurised air system shall be kept dry and free from injurious contaminants, including salts, oil and grease. Recycled blasting material shall be checked for cleanliness and size at regular intervals (to be specified in APS/ITP and recorded in the Daily Log). Checking of oil contamination and soluble contaminants shall be carried out according to ASTM D4285 and ASTM D4940, respectively. Special precautions shall be taken to avoid contamination of blasting materials for stainless steel linepipe (to be specified in APS). Conditioning of grit during production shall be described in the APS/ITP.

6.8.6 For stainless steel pipes, abrasives shall be based on fused aluminium oxide, stainless steel shot or non-ferrous garnet according to an appropriate standard. Any brushing or grinding shall be carried out using stainless steel tools only. Precautions shall be taken to avoid contamination by e.g. residual carbon steel particles, carbon steel tools and handling equipment.

6.8.7 During blast cleaning or brushing, the pipe surface shall be at least 3°C above the dew point temperature. Pre-heating of pipes is required if the initial temperature of pipe surface is less than 3°C above the dew temperature.

6.8.8 Dust or abrasive residues shall be removed from the pipe surface using dry clean air, vacuum cleaning, brushing or an equivalent technique. Compressed air quality shall be controlled (to be specified in APS/ITP). Verification of surface cleanliness and roughness shall be detailed in the ITP for compliance with the applicable type of FJC/CFR and infill system in Sec. 7 and Sec. 8, respectively. Measurements of residual salt contamination may be performed using special proprietary equipment if specified in the ITP, and provided that compliance with the referenced standard can be demonstrated. Prepared joints not meeting specified requirements shall be subject to new surface treatment. In case of repeated failures during fractional testing of surface treatment (i.e. sequential inspection of pipe joints), the testing frequency shall be increased until the efficiency of corrective actions has been confirmed.

Guidance note:

To avoid problems during production of FJC, testing of chloride contamination should be performed in advance at cut-backs so that measures can be taken to remove such contamination prior to welding (e.g. using washing by high-pressure fresh water).

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6.8.9 Precautions shall be taken to avoid rusting and/or contamination after completed surface preparation. The affected areas shall be efficiently shielded from atmospheric precipitation, sea spray, etc. Requirements to maximum duration between blasting and coating, and/or maximum relative humidity during storage shall be specified in the APS/ITP.

6.8.10 Cleaning of the pipeline coating overlap area is normally required to remove any contamination or thermal degradation of the coating surface by steel surface preparation or previous handling. Such cleaning and any further mechanical preparation of parent coating cutback for FJC/CFR shall be specified in APS/ITP.

6.9 Coating application

6.9.1 This sub-section covers and amends the requirements in ISO 21809-3 (2008), sub-section 9.2.

6.9.2 All coating application work shall be carried out according to the qualified APS and ITP (see 6.1 and 6.2, respectively). Methods, acceptance criteria and frequency and/or extent of inspection and testing shall comply with requirements given for specific types of FJC/CFR (Sec. 7) and infill (Sec. 8) and any amendments in purchase documents (see 5.4). Once APS and ITP have been qualified, any changes of materials, equipment and essential process parameters shall be formally accepted by Purchaser through a CR.

6.9.3 Coating application temperature, any pre-heating of coating materials, and drying or curing conditions shall comply with Manufacturer's recommendations (see 6.6.4) and/or the qualified APS/ITP.

6.9.4 Linepipe coating shall be shielded from any detrimental-effects of pre-heating of steel surface and coating application. The control of heating shall ensure that any accidental heating of the pipe wall to a temperature higher than 275°C is prevented. Flux shields may be required to prevent excessive heating of parent coating by induction heating. Direct heating of steel surface after completed surface preparation shall be by induction heating. Heating of PE/PP parent coating overlap shall be by hot air or infrared heat. Pre-heating by gas torches is not allowed, except for FJC/CFR systems 1D and 2A.

6.9.5 Adequate shelter from rain and wind shall be provided. Throughout coating application, essential parameters affecting the quality of the coating (e.g. steel temperature and relative humidity, pre-mixing and heating of moulding components) shall be monitored and recordings noted in the "Daily Log" Equipment for monitoring (e.g. temperature and pressure sensors, injection flow meters) shall be calibrated at scheduled intervals as specified in the ITP.

6.9.6 Control of coating application parameters shall be sufficient to verify that individual layers of coating are applied within the qualified temperature range and time frame for the application of individual layers, in order to achieve the specified coating thickness, inter-layer adhesion and other properties of each layer.

Guidance note:

For more complex FJC systems, this will normally require use of automatic control of heating and coating application process parameters.

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6.10 Inspection and testing of applied coating

6.10.1 Completed FJC/CFR and infill shall be inspected and tested according to the ITP and APS. Methods, acceptance criteria and frequency and/or extent of inspection and testing shall comply with requirements given for specific types of FJC/CFR (Sec. 7), infill (Sec. 8) and any amendments in purchase documents (see 5.4). Any changes in methods and frequency of inspection/testing shall be formally accepted by Purchaser through a CR.

Guidance note:

Inspection of FJC/CFR and infill during production is to a large extent based on visual inspection. It is essential that acceptance criteria are defined in quantitative and objective terms as far as practical, based on results from the PQT/PPT and/or previous experience. Photographic documentation of acceptable contra non-acceptable defects may be helpful. Note that monitoring/recording of the processing parameters is a crucial part of the quality control.

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6.10.2 Purchaser shall be allowed to witness all inspection and/or testing. For any special hold points identified by Purchaser (see 6.2.2), Applicator shall give adequate notice for Purchaser to arrange for witnessing. Purchaser may further specify that each FJC/CFR and infill shall be formally accepted by an inspector of his choice.

Guidance note:

Purchaser should consider the need for and benefit of carrying out quality surveillance during production, either as single audits or continuous presence by trained and qualified inspectors.

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6.10.3 Purchaser may specify testing of specific coating properties by destructive testing during production. Such testing may then be carried out on a dummy pipe piece or on an actual field joint to be stripped and recoated (or possibly repaired if accepted by Purchaser) after testing.

6.10.4 Failures during testing which are obviously due to defective sampling or operational errors of testing equipment may be disregarded and testing repeated on the same FJC/CFR. This shall be stated in the Daily Log together with any corrective measures.

6.10.5 Individual FJC/CFR and infill not meeting specified criteria shall be stripped and recoated, or if possible, repaired according to an accepted procedure (see 6.11).

6.10.6 In case of repeated failures to meet specified requirements, production shall be discontinued. Applicator shall then carry out an examination of the cause(s) of the failure and issue a “non-conformance report”.

6.10.7 All data from inspection and testing of FJC/CFR and infill, major repairs and stripping of FJC, recordings of essential operating parameters, calibration of testing and monitoring equipment and time of completed application shall be noted in the Daily Log (see 6.3). The inspection data shall be traceable to unique pipe numbers and/or joint numbers, and also to individual coating material batches or lots. The Daily Log shall be updated on a daily basis and be available for Purchaser’s review at any time during coating work.

6.11 Repairs and stripping

6.11.1 Permissible FJC and infill repairs, if applicable, as well as requirements to documentation of repairs, shall be agreed (see 5.3.1) and included in the APS (see 6.1) and ITP (see 6.2). All repairs shall be carried out and inspected according to a qualified procedure (see 6.4).

6.11.2 Stripping of un-repairable FJC and infill for re-coating shall be carried out according to a procedure accepted by Purchaser (see 6.4). It shall be demonstrated during the PQT and/or PPT that the stripping does not damage the adjacent linepipe coating or linepipe steel surface. If heating is applied, the temperature control shall ensure that heating of the pipe above 275°C is avoided.

6.11.3 The acceptable size and frequency of FJC repairs and the repair procedures shall be subject to agreement (preferably to be specified in purchase documents, see 5.3.1).

6.11.4 All repairs shall be noted in the Daily Log and shall be traceable to individual batches of coating repair materials.

6.12 Pipe tracking and marking

6.12.1 Specific requirements to pipe tracking (e.g. electronic format) and marking shall be specified in purchase documents (5.3.1). In case the purchase documents refer to a specific part of ISO 21809, the requirements to marking in this standard shall apply. Applicator’s marking and pipe tracking shall be described in the APS (see 6.1) and marking included as a specific activity in the ITP (see 6.2).

6.12.2 On receipt, every linepipe shall be identified by a unique number (i.e. as applied by pipe manufacturer) and any additional marking made by Applicator to maintain identity shall be performed as specified or accepted by Purchaser. Any intermediate storage of pipes shall be according to 6.13.

6.12.3 For documentation to be submitted by Applicator prior to start of coating activities, including the PQT, reference is made to 6.14.

6.12.4 Results from inspection and testing during qualification and production shall be documented and be traceable to unique pipe numbers and individual coating material batches or lots. Recordings of essential process parameters and inspection of repairs shall be included. For specific requirements to the Daily Log, see 6.3.

6.13 Handling and storage of pipes

6.13.1 If included in Applicator’s scope of work (e.g. FJC of stalks), pipes shall be handled and stored such that damage to coated as well as uncoated surfaces is avoided. Stainless steel pipes require special considerations to avoid surface contamination (e.g. from use of carbon steel tools and handling equipment). The applicable procedure for handling and storage of pipes shall be contained in the APS (see 6.1) and is subject to acceptance by Purchaser.

6.13.2 Damage to coatings during handling or storage shall be repaired according to 6.11 and Sec. 7, whilst any damage to linepipe material shall be reported to Purchaser. (Pipes with damage to linepipe material shall be separated and quarantined).

6.14 Documentation

6.14.1 Minimum time for supply of documentation prior to PQT and start of production shall be specified in purchase documents (5.3.1).

6.14.2 Prior to PQT (see 6.4), Applicator shall submit the following documents to Purchaser:

- APS (see 6.1) covering PQT and production (Purchaser acceptance is required for special items, see 6.1.2)
- ITP (see 6.2) covering PQT
- tentative Daily Log format (see 6.3)

6.14.3 Prior to start of production (and PPT), Applicator shall submit the following documents to Purchaser for acceptance:

- PQT report (see 6.4.15)
- APS for production
- ITP for production,
- Daily Log format,
- Final Documentation index (see 6.14.4).

6.14.4 Applicator shall issue as Final Documentation (also referred to as “as-built documentation” or “final data book”) a compilation of inspection document meeting the requirements given in ISO 10474, inspection certificate 3.1.B or equivalent. This document shall include:

- PQT/PPT report (see 6.4.15)
- APS for production
- ITP for production
- Approved concession requests
- Material data sheets (see 6.6.4)
- Coating material certificates (see 6.6.6 and 6.6.8)
- Daily Log’s.

Purchaser may waive the inclusion of detailed process and inspection data, specifying in purchase documents that the documentation shall be retained by Applicator for a certain period of time,

7. FJC/CFR System Specific Requirements

7.1 General

7.1.1 This section provides requirements to specific FJC/CFR systems which meets and amends the requirements in ISO 21809-3 (2008). In a few cases, relaxations are made, being subject to Owner/Purchaser acceptance. The same FJC designations are used as in the ISO standard; however, with amendments indicated by figures within parentheses. The FJC/CFR type specific requirements in this section amend the general requirements in Sec. 6 of this RP.

7.1.2 In ISO 21809-3, PQT and PPT are non-mandatory whilst a project specific PQT/PPT is mandatory for compliance with this RP (6.4.1). According to ISO 21809-3 (2008), Applicator is required to prepare an APS and ITP but Purchaser’s acceptance is an option in the standard. Nevertheless, all general requirements to quality control in Sec. 6 shall apply for compliance with this RP; including Purchaser’s acceptance of APS, ITP, Daily Log format and final documentation index.

7.1.3 Testing of adhesion (peel strength) applies to all FJC systems (except 3A) and shall use Method D1 according to ISO 21809-3 when performed for PQT, and for a PPT replacing a PQT. For testing during PPT and production in the field, Method D2 is acceptable. For testing of adhesion of CFR at PQT/PPT, see 6.4.8.

7.1.4 For CFR of superficial damage to PE/PP layers and FBE, special “melt sticks” are adequate. Such repairs are to be performed according to Manufacturer’s recommendation and shall be included in the PQT/PPT if applicable.

7.2 Type 1D: Cold applied polymeric tape (FJC only)

7.2.1 The coating materials shall meet the requirements in Table 6 of ISO 21809-3 (2008). Manufacturer’s MDS to be included in the APS shall comply with Table 8 in the standard. Manufacturer shall provide application instructions according to Table 9 of the standard. Unless otherwise agreed, batch testing shall include thickness and mechanical properties for compliance with Manufacturer’s specification (MS). Other

properties specified in Table 6 of the standard shall be documented in the PQT/PPT report by inclusion of a “test report” based on non-specific testing according to ISO 10474 type 2.2 or equivalent.

Guidance note:

For polymeric tapes, ISO 21809-3 (2008) refers to a primer; however, for submarine pipelines it has been common practice to apply the tape directly on the steel surface. According to this RP, use of primer is not mandatory unless specified by Purchaser.

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7.2.2 Surface preparation shall comply with section 10.3 of ISO 21809-3 (2008). However, the standard specifies blast cleaning according to ISO 8501-1 grade Sa 2. For offshore pipelines this preparation may not be practical and according to this RP, Purchaser may specify or agree to power-tool cleaning according to ISO 8504-3 and a surface cleanliness of ISO 8501, grade St 3.

During PQT/PPT and production, each joint shall be checked for surface cleanliness. In addition, dust contamination after completed surface preparation shall be checked according to ISO 8502-3 and with an acceptance criterion of grade 3 maximum. All joints shall be checked for dust during PQT/PPT and during production at start of each shift and with a subsequent frequency of 3 times per shift.

Guidance note:

There is no published evidence that a residual salt contamination after brushing to St 3 affects the performance of the coating. Hence, testing residual salts is not included in this RP (or in ISO 21809-3).

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7.2.3 Nominal minimum as-applied thickness (including overlap) shall be 1.5 mm. For compliance with this RP, the minimum thickness recorded during PQT/PPT and production shall be minimum 85% and 50% of this value when recordings are made on pipe surface and weld cap, respectively. Coating application shall comply with section 10.4 of ISO 21809-3(2008). A PPT is sufficient (i.e. PQT is not required) provided it is carried out in due time before start of production to allow for the specified testing and Purchaser’s review and acceptance of the report.

7.2.4 All testing shall be performed according to the procedures in section 10.5 and the applicable Annex of ISO 21809-3 (2008)

7.2.5 Testing of FJC during PQT/PPT shall be carried out according to Table O.1 (Annex O), FJC type 1D of ISO 21809-3 (2008). For offshore pipelines, this type of FJC is invariably used together with infill and testing of impact and indentation can be waived by Purchaser. Testing of CFR shall include visual examination, recording of thickness and checking of bonding according to an agreed method.

7.2.6 Testing during production shall as a minimum include visual examination and holiday testing for each completed FJC and recording of thickness. Recording of thickness shall be carried out at start of each shift and a subsequent frequency of every 10 joint. For submarine pipelines, destructive testing of FJC (e.g. peel testing) as specified in Table O.1 (Annex O) may severely disturb the welding/FJC installation process. Considering the extended requirements to quality control in this RP, Owner may waive such testing (to be specified in purchase document). In case of failure of the destructive testing, Applicator shall issue an NC report and take immediate actions to improve the application process. All results from testing during production shall be recorded in Daily Log for each FJC.

7.3 Type 2A(1)/2A(2): PE/PP heat shrink sleeve without primer (FJC and CFR)

7.3.1 For Type 2A (1) and Type 2A (2) the applied coating shall meet the requirements in Table 13 of ISO 21809-3 (2008), except that for impact strength and indentation of Type 2A (2) the properties of Type 2 in Table 14 apply. For CFR using PE patches, Manufacturer may specify the use of a mastic filler to be applied as a “primer”. Manufacturer’s MDS for inclusion in the APS shall comply with Table 16 in the standard. Manufacturer shall further provide application instructions according to Table 17 of the standard. Unless otherwise agreed, batch wise testing of coating materials shall include thickness and mechanical properties for compliance with Manufacturer’s specification (MS).

7.3.2 Surface preparation shall comply with section 11.3 of ISO 21809-3 (2008). However, the standard specifies blast cleaning according to ISO 8501-1 grade Sa 2.5. For offshore pipelines this preparation may not be practical and according to this RP, Purchaser may specify or agree to power tool cleaning according to ISO 8504-3 and a surface cleanliness of ISO 8501, grade St 3 (to be verified for each joint).

Guidance note:

A rotary sanding disc may be more efficient than wire brushing for power tool cleaning.

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During PQT/PPT and production, each joint shall be checked for surface cleanliness. In addition, dust contamination after completed surface preparation shall be checked according to ISO 8502-3 and with an

acceptance criterion of Grade 3 maximum. All joints shall be checked for dust during PQT/PPT and during production at start of each shift and with a subsequent frequency of 3 times per shift.

Guidance note:

There is no published evidence that a residual salt contamination after brushing to St 3 affects the performance of the applied coating. Hence, testing residual salts is not included in this RP (or in ISO 21809-3).

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7.3.3 Nominal as-applied thickness shall be minimum 1.5 mm. For compliance with ISO 21809-3 (2008), the minimum thickness recorded during PQT/PPT and production shall be minimum 85% and 50% of this value when recordings are made on pipe surface and weld cap, respectively. Coating application shall comply with section 11.4 of ISO 21809-3 (2008). A PPT is sufficient (i.e. PQT is not required) provided it is carried out in due time before start of production to allow for the specified testing and Purchaser's review and acceptance of the report.

7.3.4 All testing shall be performed according to the procedures in section 11.5 and the applicable Annex of ISO 21809-3 (2008).

7.3.5 Testing during PQT/PPT shall be carried out according to Table O.1 (Annex O), FJC type 2A of ISO 21809-3 (2008). For offshore pipelines, this type of FJC is invariably used together with infill and testing of impact, shear strength and indentation can be waived by Purchaser. Testing of peel strength after thermal ageing according to Table 13 of the standard shall be documented in the PQT/PPT report by inclusion of a "test report" based on non-specific testing according to ISO 10474 type 2.2 or equivalent. Testing of CFR shall include visual examination, recording of thickness and checking of bonding.

7.3.6 Testing during production shall as a minimum include visual examination and holiday testing for each completed FJC and recording of thickness. Recording of FJC thickness shall be carried out at start of each shift and a subsequent frequency of every 10 joints. For CFR, thickness shall be recorded for each repair. For submarine pipelines, destructive testing of FJC (e.g. peel testing) as specified in Table O.1 (Annex O) may severely disturb the welding/FJC installation process. Considering the extended requirements to quality control in this RP, Owner may waive such testing (to be specified in purchase document). In case of failure of the destructive testing, Applicator shall issue an NC report and take immediate actions to improve the application process. All results from testing during production shall be recorded in Daily Log for each FJC.

7.4 Type 2B(1) PE heat shrink sleeve with LE primer (FJC and CFR)

7.4.1 Whilst ISO 21809-3 specifies LE and FBE as options for Type 2B FJC, Type 2B (1) in this RP refers to LE only applied manually by brushing. The coating materials shall meet the requirements in Table 14 of ISO 21809-3. Manufacturer's MDSs for LE primer and shrinkable material for inclusion in the APS shall comply with the standard's Table 15 and 16, respectively. Manufacturer shall further provide application instructions according to Table 17 of the standard. Unless otherwise agreed, batch testing shall include thickness and mechanical properties for compliance with Manufacturer's specification (MS). Other properties specified in Table 14 of the standard shall be documented in the PQT/PPT report by inclusion of a "test report" based on non-specific testing according to ISO 10474 type 2.2 or equivalent.

7.4.2 Surface preparation shall comply with section 11.3 of ISO 21809-3 (2008) which includes blast cleaning according to ISO 8501-1 grade Sa 2.5. Testing of surface preparation shall include testing of dust contamination (Grade 3 maximum according to ISO 8502-3) and recording of surface roughness in accordance with ISO 8503-4 or ISO 8503-5 for PQT/PPT and during FJC production at start of each shift and with a subsequent frequency of 3 times per shift.

During production, other joints and all CFRs shall be checked for surface roughness according to ISO 8503-2. For FJC, testing of soluble salts (max. 20 mg/m² as NaCl) shall be performed according to ISO 8502-6 or ISO 8502-9. The frequency shall be as for dust testing; however, subject to acceptance of Purchaser the frequency may be reduced based on successful testing.

7.4.3 Nominal as-applied total thickness shall be minimum 2.0 mm. For compliance with ISO 21809-3 (2008), the minimum thickness recorded during PQT/PPT and production shall be minimum 85% and 50% of this value when recordings are made on pipe surface and weld cap, respectively. Dry film thickness of LE layer shall be minimum 0.10 mm (to be verified at PQT/PPT). Method for testing of wet film thickness (each joint during PQT/PPT and production) shall be agreed. Coating application shall comply with section 11.4 of ISO 21809-3 (2009). A PQT and a PPT are mandatory for compliance with this RP. For CFR, PE may be applied by melt stick (smaller repairs), hand held extruder or as proprietary patch material. Minimum thickness of the LE layer shall be 0.100 mm and overall minimum thickness shall comply with section 11.5 of ISO 21809-3 (2008).

7.4.4 All testing shall be performed according to the procedures in section 11.5 and the applicable Annex of the standard.

7.4.5 For FJC, testing during PQT/PPT shall be carried out according to Table O.1 (Annex O) and acceptance criteria and test methods defined in Table 14, FJC type 2B of ISO 21809-3 (2008). In addition to requirements to peel strength in Table 14, there shall be no peeling of the epoxy layer to steel surface. In case this FJC is to be used together with infill, testing of impact, shear strength and indentation can be waived by Purchaser. Testing of peel strength after thermal ageing according to Table 13 of the standard shall be documented in the PQT/PPT report by inclusion of a “test report” based on non-specific testing according to ISO 10474 type 2.2 or equivalent. Testing of CFR shall include visual examination, recording of thickness and checking of bonding.

7.4.6 Testing during production shall as a minimum include visual examination and holiday testing for each completed FJC and recording of thickness. Recording of FJC thickness shall be carried out at start of each shift and a subsequent frequency of every 10 joints. For CFR, thickness shall be recorded for each repair. For submarine pipelines, destructive testing of FJC (e.g. peel testing) as specified in Table O.1 (Annex O) may severely disturb the welding/FJC installation process. Considering the extended requirements to quality control in this RP, Owner may waive such testing (to be specified in purchase document). In case of failure of the destructive testing, Applicator shall issue an NC report and take immediate actions to improve the application process. All results from testing during production shall be recorded in Daily Log for each FJC.

7.5 Type 2C(1): PP heat shrink sleeve with LE primer (FJC and CFR)

7.5.1 Whilst ISO 21809-3 specifies LE and FBE as options for Type 2C FJC, Type 2C (1) in this RP refers to LE only applied manually by brushing.

7.5.2 Nominal as-applied total thickness shall be minimum 2.0 mm with minimum actual thickness (on steel substrate) according to the standard. For compliance with ISO 21809-3 (2008), the minimum thickness recorded during PQT/PPT and production shall be minimum 85% and 50% of this value when recordings are made on pipe surface and weld cap, respectively. Dry film thickness of LE layer shall be minimum 0.10 mm (to be verified at PQT/PPT). Method for testing of wet film thickness (each joint during PQT/PPT and production) shall be agreed. For coating materials, surface preparation, coating application and testing, the same requirements as for Type 2B(1) coatings in 7.4 of this RP shall apply. For CFR, PP may be applied by melt stick (smaller repairs), hand held extruder or as proprietary patch material.

7.5.3 For FJC, testing during PQT/PPT shall include be carried out according to Table O.1 (Annex O) and acceptance criteria and test methods defined in Table 14, FJC type 2C of ISO 21809-3 (2008). In addition to requirements to peel strength in Table 14, there shall be no peeling of the epoxy layer to steel surface. In case this type of FJC is to be used with infill, testing of impact, shear strength and indentation can be waived by Purchaser. Testing of peel strength after thermal ageing according to Table 13 of the standard shall be documented in the PQT/PPT report by inclusion of a “test report” based on non-specific testing according to ISO 10474 type 2.2 or equivalent. Testing of CFR shall include visual examination, recording of thickness and checking of bonding.

7.6 Type 3A: Fusion bonded epoxy (FBE) coating (FJC only)

7.6.1 Unless otherwise specified in the applicable sub-section, the requirements to FBE FJC Type 3A shall also apply to other FJC systems based on PE/PP/PU with an inner layer of FBE coating.

7.6.2 Unless otherwise agreed, the nominal thickness of the FJC shall be 350 minimum (min actual thickness 300 µm; any max value for actual thickness by agreement). For coating material properties, ISO 21809-3 (2008) section 12 refers to ISO 21809-2. This standard requires batch testing by Manufacturer as specified in Table 1 of ISO 21809-2. Other properties specified in Table 2 of ISO 21809-2 shall be documented in the PQT/PPT report by a “test report” based on non-specific testing according to ISO 10474 type 2.2 or equivalent.

Guidance note:

For special grades of FBE to be used on pipelines operating at high temperatures (> 110°C) and to be installed by reeling, the minimum FBE thickness as specified above may not be suitable and shall be agreed.

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7.6.3 Surface preparation shall comply with section 12.3 of ISO 21809-3 (2008), which includes blast cleaning according to ISO 8501-1 grade Sa 2.5. Testing of surface preparation shall include testing of dust contamination (Grade 2 maximum) according to ISO 8502-3 and recording of surface roughness in accordance with ISO 8503-4 or ISO 8503-5 (50-100 µm) for PQT/PPT and during FJC production at start of each shift and with a subsequent frequency of 3 times per shift. Surface roughness of each intermediate joint shall be checked according to ISO 8503-2. For FJC, testing of soluble salts (max. 20 mg/m² as NaCl) shall be performed according to ISO 8502-6 or ISO 8502-9. The frequency shall be as for dust testing; however, subject to acceptance of Purchaser the frequency may be reduced based on successful testing.

7.6.4 Coating materials shall comply with the requirements in section 7.2 of ISO 21809-2 (2007). Manufacturer’s MDS shall be included in the PQT report. Coating application shall comply with section 12.4

of ISO 21809-3 (2008). A PQT /PPT are mandatory for compliance with this RP. FBE application temperature shall be monitored by use of contact thermometer, infrared pyrometer or melt crayons (as specified in the approved APS) and recorded in Daily Log for each FJC.

7.6.5 The capability of each induction coil to achieve a steel temperature range well within the range recommended by Manufacturer at the point the induction coil has been switched off and FBE application is to start shall be verified by temperature recordings during the PQT. The capability of equipment for automatic spraying of powder coating to obtain the specified thickness range shall also be verified. The maximum time between interruption of heating and completion of powder application to achieve specified properties of the coating shall be established during the PQT. Procedures for this verification and results shall be contained in the APS and PQT report, respectively.

7.6.6 All testing shall be performed according to the procedures in section 12.5 of ISO 21809-3 (2008) and the applicable Annex of the standard.

7.6.7 Testing for PQT/PPT shall be carried out according to Table O.1, FJC type 3A of ISO 21809-3 (2008). For offshore pipelines, this type of FJC is invariably used together with infill and testing of impact and indentation can be waived by Purchaser.

7.6.8 Testing during production shall as a minimum include visual examination, and holiday testing for each completed FJC and recording of thickness. Recording of FJC thickness shall be carried out at start of each shift and a subsequent frequency of every 10 joints (not applicable for FBE coating to be immediately followed by application of PE/PP).

7.7 Type 2B(2): PE heat shrink sleeve applied on FBE coating (FJC only)

7.7.1 Whilst ISO 21809-3 specifies LE and FBE as options for Type 2B FJC, Type 2B (2) in this RP refers to FBE only, applied by automatic spraying to a minimum thickness of 300 µm. Subject to acceptance by Purchaser, manual application of FBE may be applied for FJC associated with tie-ins, coating of weld repairs on stalks and other special applications of weld sleeves. The PQT/PPT shall include one extra FJC applied without adhesive for close examination of the FBE layer.

7.7.2 For the FBE layer, the requirements for PQT/PPT and production in 7.6.2-7.6.7 of this RP shall apply, except that testing of cathodic disbondment and hot-water immersion test are not required for the FBE-layer. For the full FJC layer, the requirements for application in section 14.4 and testing of Type 5D and 5E type coatings in section 14.5 and Table O1 (Annex O) of ISO 21809-3 (2008) shall apply. In addition cathodic disbonding testing at 65°C, 24 hrs at -3.5 V (maximum 7 mm disbondment) and a hot water immersion test according to ISO 21809-1 (2011), Annex M (maximum 2 mm average disbondment and maximum 3 mm) shall be performed for the PQT. Testing for PPT (if applicable, see 6.4.1) shall as a minimum include visual examination, thickness testing, holiday testing, peel strength and degree of FBE cure according to Table 25 of ISO 21809-3, adhesion testing with maximum rating 2 according to Annex C in ISO 21809-3 and cathodic disbondment testing at 65°C, 24 hrs at -3.5 V (maximum 7 mm disbondment). FBE application temperature shall be monitored by use of contact thermometer or infrared pyrometer during PQT/PPT.

Guidance note:

Contrary to ISO 21809-1 (2011) for linepipe coating, ISO 21809-3 (2008) does not specify any requirements to PE/PP hardness and mechanical properties for FJC. Purchasers of FBE + PE/PP FJC systems should be aware of that the as-applied PE/PP properties of some Type 5 FJC systems may not fully match those of PE/PP linepipe coating.

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7.7.3 Testing of the complete FJC during production shall as a minimum include visual examination and holiday testing for each completed FJC and recording of thickness at start of each shift and a subsequent frequency of every 10 joints. For submarine pipelines, destructive testing of FJC (e.g. peel testing) as specified in Table O.1 (Annex O) may severely disturb the welding/FJC installation process. Considering the extended requirements to quality control in this RP, Owner may waive such testing (to be specified in purchase document). In case of failure of the destructive testing, Applicator shall issue an NC report and take immediate actions to improve the application process. All results from testing during production shall be recorded in Daily Log for each FJC.

7.8 Type 2C(2): PP heat shrink sleeve applied on FBE coating (FJC only)

7.8.1 Whilst ISO 21809-3 specifies LE and FBE (min. thickness not specified) as options for Type 2C FJC, Type 2C (2) in this RP refers to FBE only and minimum thickness 300 µm, applied by automatic spraying. Subject to acceptance by Purchaser, manual application of FBE may be allowed for FJC associated with tie-ins, coating of weld repairs on stalks and other special applications of heat shrink sleeves. The PQT/PPT shall include one extra FJC applied without adhesive for close examination of the FBE layer.

7.8.2 For the FBE layer, the requirements for PQT/PPT and production in 7.6.2-7.6.7 of this RP shall apply, except that testing of cathodic disbondment and hot-water immersion test are not required for the FBE-layer.

For the full FJC layer, the requirements for application in section 14.4 and testing of Type 5A, 5B and 5C type coatings in section 14.5 and Table O.1 (Annex O) of ISO 21809-3 (2008) shall apply. In addition, cathodic disbonding testing at 65°C, 24 hrs at -3.5V (max. 7 mm disbondment) and a hot water immersion test according to ISO 21809-1, Annex M (max. 2 mm average disbondment and max. 3 mm) shall be performed for the PQT. Testing for PPT (if applicable, see 6.4.1) shall as a minimum include visual examination, thickness testing, holiday testing, peel strength and degree of FBE cure according to Table 24 of ISO 21809-3 (2008), adhesion testing with maximum rating 2 according to Annex C in ISO 21809-3 and cathodic disbondment testing at 65°C, 24 hrs at -3.5V (max. 7 mm disbondment). Other testing in Table 24 of the standard is optional to Purchaser during PPT (to be specified in purchase document).

Guidance note:

Contrary to ISO 21809-1 (2011) for linepipe coating, ISO 21809-3 (2008) does not specify any requirements to PE/PP hardness and mechanical properties for FJC. Purchasers of FBE + PE/PP FJC systems should be aware of that the as-applied PE/PP properties of some Type 5 FJC systems may not fully match those of PE/PP linepipe coating.

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7.8.3 Testing of the complete FJC during production shall as a minimum include visual examination and holiday testing for each completed FJC and recording of thickness at the start of each shift and a subsequent frequency of every 10 joints. For submarine pipelines, destructive testing of FJC (e.g. peel testing) as specified in Table O.1 (Annex O) may severely disturb the welding/FJC installation process. Considering the extended requirements to quality control in this RP, Owner may waive such testing (to be specified in purchase document). In case of failure of destructive testing, Applicator shall issue an NC report and take immediate measures to improve the application process. All results from testing during production shall be recorded in Daily Log for each FJC.

7.9 Types 5A, 5B and 5C(1): PP coatings applied on FBE (FJC only)

7.9.1 Coating types 5A, 5B and 5C in ISO 21809-3 refers to PP coating applied as tape or sheet (5A), by flame spraying (5B) or injection moulding (5C) on top of a FBE or LE coating and with an intermediate PP adhesive layer. FJC of type 5B (involving manual application of FBE and PP) shall only be used for tie-in operations and repairs of field joints during stalk production. FJC Type 5C(1) refers to FJC with a thickness of maximum 10 mm as used for linepipe with 3LPP coating. Type 5C(2) refers to infill (> 10 mm) for pipes with relatively thick thermal insulation and is covered in Sec. 8. The PQT/PPT shall include one extra FJC applied without adhesive for close examination of the FBE layer.

7.9.2 For the FBE layer, the requirements in 7.6.2-7.6.7 of this RP shall apply, except that testing of cathodic disbondment and hot-water immersion test are not required for the FBE-layer. Manufacturer's MDSs for PP adhesive and PP top layer for inclusion in the APS shall comply with the standard's Table 27 and 28, respectively. Manufacturer shall further provide application instructions according to Table 29 of the standard. Batch testing of PE/PP materials is not specified in ISO 21809-3 but shall for compliance with this RP include density (ISO 1183), melt flow index/rate (ISO 1133) and moisture/water content (ISO 15512) for compliance with Manufacturer's specification (MS).

Guidance note:

Contrary to ISO 21809-1 (2011) for linepipe coating, ISO 21809-3 (2008) does not specify any requirements to PE/PP hardness and mechanical properties for FJC. Purchasers of FBE + PE/PP FJC systems should be aware of that the as-applied PE/PP properties of some Type 5 FJC systems may not fully match those of PE/PP linepipe coating.

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7.9.3 Coating application shall comply with section 14.4 of ISO 21809-3. A PQT/PPT (see 6.4.1) is mandatory for compliance with this RP. For Type 5C FJC, measures to avoid a) contamination of systems handling coating materials (e.g. by cleaning of equipment) and b) excessive heating of PP in the extruder during start-up and interruption of coating shall be described in the APS.

7.9.4 All testing shall be performed according to the procedures in section 14.5 of ISO 21809-3 and the applicable Annex of the standard.

7.9.5 For PQT/PPT, all properties in Table O.1 (Annex O) of ISO 21809-3 shall be verified. In addition cathodic disbonding testing at 65°C, 24 hrs at -3.5V (max. 7 mm disbondment) and a hot water immersion test according to ISO 21809-1, Annex M (max. 2 mm average disbondment and max. 3 mm) shall be performed for the PQT. Testing for PPT (if applicable, see 6.4.1) shall as a minimum include visual examination, thickness testing, holiday testing, peel strength and degree of FBE cure according to Table 24 of ISO 21809-3 (2008), adhesion testing with maximum rating 2 according to Annex C in ISO 21809-3 and cathodic disbondment testing at 65°C, 24 hrs at -3.5V (max. 7 mm disbondment). Other testing in Table 24 of the standard is optional to Purchaser during PPT (to be specified in purchase document).

7.9.6 Testing during production shall as a minimum include visual examination and holiday testing for each completed FJC and recording of total thickness. Recording of total thickness shall be carried out at start of each

shift and a subsequent frequency of every 10 joints. Contrary to all other types of FJC systems, ISO 21809-3 does not specify any testing of adhesion for Type 5 coating systems during production, although such systems are not less susceptible irregularities in quality control. Owner/Purchaser should duly consider the specification of such testing although it is largely impractical during current offshore installation and then need to be carried out during e.g. interrupted installation. Testing of adhesion to parent coating according to the D2 procedure of ISO 21809-3 can be performed without need for subsequent repair whilst testing of adhesion to steel substrate shall be repaired by a qualified procedure. For the latter testing, properties of the FBE layer should also be verified. In case of failure of the destructive testing, Applicator shall issue an NC report and take immediate actions to improve the application process.

All results from testing during production shall be recorded in Daily Log for each FJC.

7.10 Types 5D(1) and 5E: PE coatings applied on FBE (FJC only)

7.10.1 Coating types 5D and 5E in ISO 21809-3 refers to PE coating applied by flame spraying (5D) or as tape/sheet on top of a FBE or LE coating and with an intermediate PE adhesive layer. FJC of type 5B (involving manual application of FBE and PP) shall only be used for tie-in operations and repairs of stripped FJC during stalk production. FJC Type 5D (1) refers to FJC with a thickness of maximum 10 mm as used for linepipe with 3LPP coating. Type 5D (2) refers to infill (> 10 mm) for pipes with relatively thick thermal insulation and is covered in Sec. 8. The PQT/PPT shall include one extra FJC applied without adhesive for close examination of the FBE layer.

7.10.2 For the FBE layer, the requirements in 7.6.2-7.6.7 of this RP shall apply, except that testing of cathodic disbondment and hot-water immersion test are not required for the FBE layer. Manufacturer's MDSs for modified PE and PE top layer for inclusion in the APS shall comply with the standard's Table 27 and 28, respectively. Manufacturer shall further provide application instructions according to Table 29 of the standard. Batch testing of PE/PP materials is not specified in ISO 21809-3 but shall for compliance with this RP include density (ISO 1183), melt flow index/rate (ISO 1133) and moisture/water content (ISO 15512) for compliance with Manufacturer's specification (MS)

Guidance note:

Contrary to ISO 21809-1 (2011) for linepipe coating, ISO 21809-3 (2008) does not specify any requirements to PE/PP hardness and mechanical properties for FJC. Purchasers of FBE + PE/PP FJC systems should be aware of that the as-applied PE/PP properties of some Type 5 FJC systems may not fully match those of PE/PP linepipe coating.

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7.10.3 Coating application shall comply with section 14.4 of ISO 21809-3 (2008). A PQT/PPT (see 6.4.1) is mandatory for compliance with this RP.

7.10.4 All testing shall be performed according to the procedures in section 14.5 of ISO 21809-3 (2008) and the applicable Annex of the standard.

7.10.5 For PQT/PPT, all properties in Table O.1 (Annex O) of ISO 21809-3 (2008) shall be verified. In addition cathodic disbonding testing at 65°C, 24 hrs at -3.5V (max. 7 mm disbondment) and a hot water immersion test according to ISO 21809-1, Annex M (max. 2 mm average disbondment and max. 3 mm) shall be performed for the PQT. Testing for PPT (if applicable, see 6.4.1) shall as a minimum include visual examination, thickness testing, holiday testing, peel strength and degree of FBE cure according to Table 25 of ISO 21809-3, adhesion testing with maximum rating 2 according to Annex C in ISO 21809-3 and cathodic disbondment testing at 65°C, 24 hrs at -3.5V (maximum 7 mm disbondment). FBE application temperature shall be monitored by use of contact thermometer or infrared pyrometer during PQT/PPT. For relatively thick FJC of type 5C the peel test specified in ISO 21809-3 requires that the thickness of the PE coating is reduced.

7.10.6 Testing during production shall as a minimum include FBE visual examination and holiday testing for each completed FJC and recording of total thickness. Contrary to all other types of FJC systems, ISO 21809-3 does not specify any testing of adhesion for Type 5 coating systems during production, although such systems are not less susceptible irregularities in quality control. Owner/Purchaser should duly consider the specification of such testing although it is largely impractical during current offshore installation and then need to be carried out during e.g. interrupted installation. Testing of adhesion to parent coating according to the D2 procedure of ISO 21809-3 can be performed without need for subsequent repair whilst testing of adhesion to steel substrate shall be repaired by a qualified procedure. For the latter testing, properties of the FBE layer should also be verified. In case of failure of the destructive testing, Applicator shall issue an NC report and take immediate actions to improve the application process.

All results from testing during production shall be recorded in Daily Log for each FJC.

7.11 Type 8A: Polychloroprene coatings (FJC only)

7.11.1 Polychloroprene FJC is typically used for linepipe coating in the same material type and is mostly applied by the same contractor. Manufacturer's MDS for inclusion in the APS shall comply with Table 37 in ISO 21809-3 (2008). Manufacturer shall further provide application instructions according to Table 39 of the

standard. Batch testing of polychloroprene material shall as a minimum include specific gravity and rheometer recording for all batches, tensile strength, elongation and tear strength for every 10 batch. Other properties specified in Table 37 of the standard shall be documented in the PQT/PPT report by a “test report” based on non-specific testing according to ISO 10474 type 2.2 or equivalent. For polychloroprene coatings, resistance to disbondment is of special concern and shall be documented for the applicable design conditions as agreed with Purchaser.

7.11.2 Surface preparation shall comply with section 17.3 of ISO 21809-3 (2008) which includes blast cleaning according to ISO 8501-1 grade Sa 2.5. Testing of surface preparation shall include testing of dust contamination (Grade 2 maximum) according to ISO 8502-3. Surface roughness shall be recorded in accordance with ISO 8503-4 or ISO 8503-5 (50-100 μm) for PQT/PPT, and during FJC production at start of each shift and with a subsequent frequency of 3 per shift. For FJC, testing of soluble salts (max. 20 mg/m^2 as NaCl) shall be performed according to ISO 8502-6 or ISO 8502-9. Surface roughness of intermediate joints shall be checked according to ISO 8503-2. The frequency shall be as for dust testing; however, subject to acceptance of Purchaser the frequency may be reduced based on successful testing.

7.11.3 Coating application shall comply with section 17.4 of ISO 21809-3 (2008). A PPT is sufficient provided it is carried out in due time before start of production to allow for the specified testing and Purchaser’s review and acceptance of the report.

7.11.4 All testing shall be performed according to the procedures in section 17.5 and the applicable Annex of the standard.

7.11.5 For PQT/PPT, all properties in Table O.1 (Annex O) of ISO 21809-3 shall be verified. Testing during production shall as a minimum include visual examination (every joint), recording of thickness and hardness (every 10 joint) and adhesion (once per shift) in compliance with the minimum requirements of the standard. All results from testing during production shall be recorded in Daily Log for each FJC.

8. Infill System Specific Requirements

8.1 General

8.1.1 This RP covers infill based on PU, either as foamed or as solid PU, and based on PP. Such infill is used for concrete coated pipes and for pipes with relatively thick (> 10 mm) thermal insulation on PU or PP basis (see 1.2.3). In the first case, the infill is to provide a smooth surface during installation (typically by S-laying) and mechanical protection during operation; resistance to impacts e.g. by trawling boards. In the second case, the actual pipeline is typically installed by reeling followed by burial. Thermal insulation capacity and resistance to cracking during installation are then primary properties. In this section, reference is made to requirements to specific types of FJC in ISO 21809-3 with amendments in Sec. 7 of this RP.

8.1.2 For concrete coated pipes, PU infill is typically applied on top of FJC systems 1D and 2A in Sec.1.2. For pipes with thermal insulation, PU infill is mostly applied directly on the steel substrate after application of a thin primer layer applied as a liquid, whilst PP infill is applied on top of a FBE layer with an intermediate PP adhesive.

8.1.3 PU infill to be used for pipes operating at a temperature exceeding 70°C need to be qualified to document resistance to degradation of mechanical and thermal insulation properties. The same applies to PP infill and FBE for use at operating temperatures above 110°C . Such qualification is not covered by this RP.

8.1.4 All general requirements to quality control in Sec. 5 and 6 in this RP shall apply, including the preparation of APS, ITP, Daily Log format and final documentation index for Purchaser’s approval, and the execution of a project specific PQT and a PPT.

8.2 Type 4E(1): Moulded PU with primer applied on steel surface

8.2.1 The requirements to PU based FJC type 4E in ISO 21809-3 shall apply. Manufacturer’s MDS (primer and PU components) in the APS shall comply with Table 21 of this standard. Manufacturer shall further provide application instructions according to Table 22 of the standard. Batch testing of PU components and primer is not specified in ISO 21809-3 but shall for compliance with this RP include testing of viscosity and gravity as a minimum. Furthermore, for each batch of the polyol component, gel time, hardness and density of the mixed product shall be certified for compliance with MS. Other material properties of the mixed PU product specified in Table 20 of the standard shall be documented in the PQT/PPT report by a “test report” based on non-specific testing according to ISO 10474 type 2.2 or equivalent. For PU coatings operating at temperatures above 70°C , resistance to thermal degradation is of special concern and shall be documented for the applicable design conditions.

8.2.2 Description of devices for moulding, including drawing of any permanent sheeting and strapping shall be included in the APS.

8.2.3 Surface preparation shall comply with section 13.3 of ISO 21809-3 (2008), which includes blast cleaning according to ISO 8501-1 grade Sa 2.5. Testing of surface preparation shall include testing of dust contamination (max. grade 2) according to ISO 8502-3. Surface roughness shall be recorded in accordance with ISO 8503-4 or ISO 8503-5 (50-100 μm) for PQT/PPT, and during FJC production at start of each shift and with a subsequent frequency of every 10 joints. Surface roughness of intermediate joints shall be checked according to ISO 8503-2. For FJC, testing of soluble salts (max. 20 mg/m^2 as NaCl) shall be performed according to ISO 8502-6 or ISO 8502-9. The frequency shall be as for dust testing; however, subject to acceptance of Purchaser the frequency may be reduced based on successful testing. Overlap of parent coating is further to be prepared to provide adequate adhesion (to be described in APS).

8.2.4 Coating application shall comply with section 13.4 of ISO 21809-3 (2008). Coating application shall be preceded by a visual examination of the linepipe coating overlap to confirm that the surfaces to be coated are clean, dry and have a temperature as specified in the APS. Control of injection rates, temperatures and mixing of PU components shall be performed as detailed in the APS. A PQT and PPT is mandatory for compliance with this RP.

8.2.5 All testing shall be performed according to the procedures in section 13.5 and the applicable Annex of ISO 21809-3 (2008)

8.2.6 Testing during PQT/PPT shall as a minimum include visual examination, holiday testing, density according to MS, thickness and compressive strength with method and acceptance criteria as defined in Table 20 in ISO 21809-3 (2008) and peel strength to steel substrate and parent coating. Peel strength shall be performed according to Annex D in ISO 21809-3 (2008) and method D1 (mandatory during PQT) with acceptance criteria 8 N/mm. During PPT method D2 may be used. For the PQT, Purchaser may specify full scale impact test according to DNV-RP-F111. Details of testing including impact force, shape of impacting hammer and acceptance criteria shall then be agreed, preferably in purchase documents. Purchaser may specify other testing (e.g. hardness) according to Table 20 of the standard.

8.2.7 For pipelines to be installed by reeling, the PQT shall include a full scale bending test with conditions specified by Purchaser or agreed (including min. bending radius and temperature of testing). The test shall be evaluated by visual examination for surface breaking cracks and internal disbondment requiring sectioning of the infill/FJC after completed testing. Testing conditions and acceptance criteria shall be agreed prior to testing, preferably in purchase documents (see Sec. 5), for inclusion in the APS.

Guidance note:

Cracking and disbondment of the infill during bend testing may be initiated by cracking/disbondment initiated in the linepipe coating.

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8.2.8 Testing during production shall as a minimum include visual examination on each joint and density once per shift. Essential process parameters (e.g. injection rates and temperatures) shall be monitored and recorded. Purchaser may specify peel testing of the parent coating overlap according to the D2 procedure of ISO 21809-3 (testing can be performed without need for subsequent repair) and hardness testing.

8.3 Type 4E(2): Moulded PU (foamed or solid) applied on top of FJC Type 1D or 2A

8.3.1 For the inner FJC, the general requirements in section 7.1 and the FJC Type specific requirements in sections 7.2 and 7.3, respectively shall apply. For the PU components, Manufacturer's MDS for the APS shall comply with Table 21 of ISO 21809-3 (2008). Batch testing of PU components and primer is not specified in ISO 21809-3 but shall for compliance with this RP include testing of viscosity and gravity as a minimum. Furthermore, for each batch of the polyol component, gel time, hardness and density of the mixed product shall be certified. for compliance with MS. Compressive strength and water absorption as specified in Table 20 of the standard shall be documented in the PQT/PPT report by a "test report" based on non-specific testing according to ISO 10474 type 2.2 or equivalent. Any materials for moulding to be left on the FJ after installation (e.g. sheeting and straps) shall also be described in MDSs attached to the APS.

8.3.2 Surface preparation prior to FJC application shall be performed as specified in sections 7.2 and 7.3, respectively. Devices for moulding, including drawing of any permanent sheeting and strapping shall be described and listed in the APS.

8.3.3 Coating application shall be preceded by a visual examination of the applied FJC and linepipe coating overlap to confirm that the surfaces to be coated are clean, dry and have a temperature as specified in the APS. Control of injection rates, temperatures and mixing of PU components shall be performed as detailed in the APS. A PQT and a PPT are mandatory for compliance with this RP.

8.3.4 All testing shall be performed according to the procedures in section 13.5 and the applicable Annex of ISO 21809-3 (2008).

8.3.5 Testing of infill during PQT, PPT and production shall be as specified in 8.2.6-8.2.8.

8.4 Type 4E(3): Moulded PU applied on top of an FBE layer (FJC Type 3A)

8.4.1 For the FBE layer the requirements in 7.6.2-7.6.7 of this RP shall apply. The requirements to PU based FJC type 4E in ISO 21809-3 shall apply. Manufacturer's MDS (primer and PU components) to be included in the APS shall comply with Table 21 of this standard. Manufacturer shall further provide application instructions according to Table 22 of the standard. Batch testing of PU components and primer is not specified in ISO 21809-3 but shall for compliance with this RP include testing of viscosity and gravity as a minimum. Furthermore, for each batch of the polyol component, gel time, hardness and density of the mixed product shall be certified. Other material properties specified in Table 20 of the standard shall be documented in the PQT/PPT report by a "test report" based on non-specific testing according to ISO 10474 type 2.2 or equivalent. For PU coatings operating at temperatures above 70°C, resistance to thermal degradation is of special concern and shall be documented for the applicable design conditions

8.4.2 Description of devices for moulding, including drawing of any permanent sheeting and strapping shall be included in the APS.

8.4.3 Coating application shall be preceded by a visual examination of the applied FJC and linepipe coating overlap to confirm that the surfaces to be coated are clean, dry and have a temperature as specified in the APS. Control of injection rates, temperatures and mixing of PU components shall be performed as detailed in the APS. A PQT and a PPT are mandatory for compliance with this RP

8.4.4 Testing of infill during PQT, PPT and production shall be as specified in 8.2.5-8.2.8. Owner/Purchaser should duly consider the specification of adhesion (peel) testing although it is largely impractical during current offshore installation and then need to be carried out during e.g. interrupted installation. For FJC of stalks, testing of adhesion to parent coating according to the D2 procedure of ISO 21809-3 can be performed without need for subsequent repair whilst testing of adhesion to steel substrate shall be repaired by a qualified procedure. For the latter testing, properties of the FBE layer should also be verified

8.5 Type 5C(2): Moulded PP applied on top of an FBE layer (FJC Type 3A) with intermediate layer of PP adhesive

8.5.1 For the FBE layer the requirements in 7.6.2-7.6.7 of this RP shall apply. For the PP materials (PP adhesive and PP for moulding), the requirements in 7.9.2 of this RP apply.

8.5.2 Description of devices for moulding, including drawing of any permanent sheeting and strapping shall be included in the APS.

8.5.3 Coating application shall be preceded by a visual examination of the applied FJC and linepipe coating overlap to confirm that the surfaces to be coated are clean, dry and have a temperature as specified in the APS.

8.5.4 A PQT is mandatory and can replace a PPT if it is carried out in the FJC production facility (e.g. welding yard for production of stalks for reeling). Testing shall be carried out according to Table 24 of ISO 21809-3 with amendments in section 7.9 of this RP, except that testing of impact and indentation resistance shall apply. For testing of resistance to peel and cathodic disbondment, the PP layer shall be reduced to an adequate thickness for testing according to the D1 procedure of ISO 21809-3.

8.5.5 For pipelines to be installed by reeling, the PQT shall include a full scale bending test (see 6.4.13) with conditions specified by Purchaser or agreed (including min. bending radius and temperature of testing). The test shall be evaluated by visual examination for surface breaking cracks and internal disbondment requiring sectioning of the infill/FJC after completed testing. Testing conditions and acceptance criteria shall be agreed prior to testing, preferably in purchase documents, for inclusion in the APS.

Guidance note:

Cracking and disbondment of the infill during bend testing may be initiated by cracking/disbondment initiated in the linepipe coating. Mismatch in wall thickness and pipe material strength relative to weld metal may further affect sensitivity to such cracking as well as the properties of the factory finished cut-backs of the linepipe coating. Based on these considerations, Purchaser should consider specifying the inclusion of real girth welds for such testing.

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8.5.6 Testing during production shall as a minimum include visual examination. Criteria for such examination shall be detailed in the APS. Essential process parameters (e.g. injection rate and injection temperature) shall be monitored and recorded. Owner/Purchaser should duly consider the specification of adhesion (peel) testing although it is largely impractical during current offshore installation and then need to be carried out during e.g. interrupted installation. For FJC of stalks, testing of adhesion to parent coating according to the D2 procedure of ISO 21809-3 can be performed without need for subsequent repair whilst testing of adhesion to steel substrate shall be repaired by a qualified procedure. For the latter testing, properties of the FBE layer should also be verified.

8.6 Type 5C(1): Moulded PE applied on top of an FBE layer (FJC Type 3A) with intermediate layer of PP adhesive

8.6.1 Besides the exceptions and amendments specified in this sub-section, the requirements to coating materials, surface preparation, coating application and testing for Type 5D(1) FJC in section 7.10 of this RP shall apply.

8.6.2 Description of devices for moulding, including drawing of any permanent sheeting and strapping shall be included in the APS.

8.6.3 Coating application shall be preceded by a visual examination of the applied FJC and linepipe coating overlap to confirm that the surfaces to be coated are clean, dry and have a temperature as specified in the APS.

8.6.4 A PQT is mandatory and can replace a PPT if it is carried out in the FJC production facility (e.g. welding yard for production of stalks for reeling). Testing shall be carried out according to Table 25 of ISO 21809-3 with amendments in section 7.10 of this RP. For testing of resistance to peel and cathodic disbondment, the PE layer shall be reduced to an adequate thickness for testing according to the D1 procedure of ISO 21809-3.

8.6.5 For pipelines to be installed by reeling, the PQT shall include a full scale bending test with conditions specified by Purchaser or agreed (including min. bending radius and temperature of testing). The test shall be evaluated by visual examination for surface breaking cracks and internal disbondment requiring sectioning of the infill/FJC after completed testing. Testing conditions and acceptance criteria shall be agreed prior to testing, preferably in purchase documents, for inclusion in the APS.

Guidance note:

Cracking and disbondment of the infill during bend testing may be initiated by cracking/disbondment initiated in the linepipe coating. Mismatch in wall thickness and pipe material strength relative to weld metal may further affect sensitivity to such cracking as well as the properties of the factory finished cut-backs of the linepipe coating. Based on these considerations, Purchaser should consider specifying the inclusion of real girth welds for such testing.

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8.6.6 Testing during production shall as a minimum include visual examination. Criteria for such examination shall be detailed in the APS. Essential process parameters (e.g. injection rate and injection temperature) shall be monitored and recorded. Owner/Purchaser should duly consider the specification of adhesion (peel) testing although it is largely impractical during current offshore installation and then need to be carried out during e.g. interrupted installation. For FJC of stalks, testing of adhesion to parent coating according to the D2 procedure of ISO 21809-3 can be performed without need for subsequent repair whilst testing of adhesion to steel substrate shall be repaired by a qualified procedure. For the latter testing, properties of the FBE layer should also be verified.

9. ANNEX 1: Inspection and Testing Plan (ITP) Format (Applicable to PQT/PPT and Production)

Reference documents:		Coating Specification (project specific doc. no)							
		APS (project specific doc. no)							
Activity number	General description	Ref. to spec.	Ref. to procedure or method/tool	Test frequency	Acceptance criteria	Reporting document	Inspection code*		
							Applicator	Purchaser	3 rd party
1 Receipt of coating and blasting materials									
1.1									
2 Inspection and marking of field joints									
2.1									
3 Surface preparation and heating									
3.1									
4 Coating application									
4.1									
5 Inspection/Testing of applied coating									
5.1									
6 Repair									
6.1									

* R=Review, I=inspection, M=Monitoring, W=Witness, H=Hold.