

# Gasunie Technical Standard

Material Specification Mechanical

MSW-11-E

**Shop coating of steel structures  
and pipeline elements**

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Intern/Internal

## FOREWORD

This specification supersedes the fourteenth version of MSW-11-E.

With respect to the former version the following has been changed:

- Clause 1: Scope expanded from natural gas to various gases and liquid.
- Clause 4: Adaptation design considerations regarding finishing sharp edges.
- Subclause 6.4.6 Transition between various coating types.
- Subclause 7.2: "Marking and identification of materials" has been changed to clause 8. Colours and marks to be used have been moved to the new clause 9 "Colour systems".
- Clauses 7, 8, 9: Update on topics of uncoated surfaces, marking and identification of materials, colour systems.
- Subclause 12.1: Coating systems: requirement added.
- Annex A.6, A.13: Change of type of coating.
- Annex B:
  - System selection table has been expanded to additional media.
  - Changes in table and notes underneath.
- Annex C and D: NEN-EN-ISO 8503-4 has been replaced by NEN-EN-ISO 8503-1.

Alterations are marked with a left margin line.

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## 1. SCOPE AND APPLICATION

This specification applies to and defines all coatings of steel structures, pressure equipment, pipes and pipeline elements for underground and above ground application, not applied in the field, with a maximum operating temperature of 220 °C and comprises the requirements for:

- coating materials;
- surface preparation;
- coating methods;
- inspection methods.

The application of additional concrete (weight) coating is not covered in this specification.

Transport-medium <sup>1</sup>	Natural gas	Hydrogen	Carbon dioxide	Nitrogen	(Hot) water	Ammonia
	Applicable	Applicable	Applicable	Applicable	Applicable	Applicable

- 1 The table is based on 100 % suitability of the transport medium concerned.  
The scope and media for which this specification is suitable are not automatically the same as the scope and media of underlying specifications. The scope and suitability for a medium are described for each specification.

## 2. REFERENCES

This specification is subject to the requirements of the documents stated in this clause.

### 2.1 Gasunie documents

Reference is made in this specification to the following Gasunie documents:

<a href="#">GTS W-013A</a>	Pre-commissioning - Inspection report on paint and coating work; in shop application.
<a href="#">GTS W-024</a>	Audit question list coating.
<a href="#">GTS W-110</a>	Qualified coating systems (CSW-55-N/1, CSW-55-N/2 & MSW-11-E).
<a href="#">GTS W-111</a>	Coatingcoderingen (Coating codes).
<a href="#">MSA-23-N</a>	Handling, opslag en kwaliteitsbewaking materialen (Handling, storage and quality inspection of materials).
<a href="#">MSA-25-E</a>	Transport packing and marking.
<a href="#">MSW-06-E</a>	Insulating joints.

### 2.2 National standards

Reference is made in this specification to the national standards mentioned in this subclause. Any supplements and errata notices are also applicable.

KIWA directive BRL-K768	Uitwendige epoxybekledingen van ondergronds te leggen stalen tanks, buizen en hulpstukken (External epoxy coatings of underground steel tanks, pipes and fittings).
KIWA directive BRL-K779	Beoordelingsrichtlijn: Inwendige bekleding op stalen tanks voor brandbare vloeistoffen (Assessment directive: internal coating on steel tanks for flammable liquids).
KIWA directive BRL-K790	Beoordelingsrichtlijn: Het appliceren van bekledingen op stalen opslagtanks of stalen leidingen en hulpstukken (Assessment directive: the application of coating systems on steel storage tanks or steel pipes and fittings).
NEN 5254	Het industrieel aanbrengen van organische deklagen op thermisch verzinkte of gesherardiseerde producten (duplex-systeem) (Industrial application of organic coatings on hot-dip zinc coated or sherardised products (duplex- system)).

## 2.3 International standards

Reference is made in this specification to the international standards<sup>1</sup> mentioned in this subclause. Any supplements and errata notices are also applicable.

DIN 30670	Polyethylene coatings of steel pipes and fittings; requirements and testings.
DIN 30678	Polypropylene coatings for steel pipes.
NEN-EN 1090-2	Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures.
NEN-EN 10289	Steel tubes and fittings for onshore and offshore pipelines - External liquid applied epoxy and epoxy-modified coatings.
NEN-EN 10290	Steel tubes and fittings for onshore and offshore pipelines - External liquid applied polyurethane and polyurethane-modified coatings.
NEN-EN-ISO 527-1	Plastics - Determination of tensile properties - Part 1: General principles
NEN-EN-ISO-527-2	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics.
NEN-EN-ISO-527-3	Plastics - Determination of tensile properties - Part 3: Test conditions for films and sheets.
NEN-EN-ISO 527-4	Plastics - Determination of tensile properties - Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites.
NEN-EN-ISO 527-5	Plastics - Determination of tensile properties - Part 5: Test conditions for unidirectional fibre-reinforced plastic composites.
NEN-EN-ISO 1461	Hot-dip galvanised coatings on fabricated iron and steel articles-Specifications and test methods.
NEN-EN-ISO 2409	Paints and varnishes – Cross-cut test.
NEN-EN-ISO 4527	Metallic coatings - Autocatalytic (electroless) nickel-phosphorus alloy coatings - Specification and test methods.
NEN-EN-ISO 4624	Paints and varnishes - Pull-off test for adhesion
NEN-EN-ISO 4628-2	Paints and varnishes - Evaluation of degradation of coatings; Designation of quantity and size of defects, and of intensity of uniform changes in appearance; Part 2: Assessment of degree of blistering.
NEN-EN-ISO 4628-3	Paints and varnishes - Evaluation of degradation of coatings; Designation of quantity and size of defects, and of intensity of uniform changes in appearance; Part 3: Assessment of degree of rusting.
NEN-EN-ISO 4628-4	Paints and varnishes - Evaluation of degradation of coatings; Designation of quantity and size of defects, and of intensity of uniform changes in appearance; Part 4: Assessment of degree of cracking.

<sup>1</sup> Applicable for all NEN-EN standards: Depending on the country where the standard will be applied, DIN-EN or BS-EN, for example, shall be chosen.

NEN-EN-ISO 4628-5	Paints and varnishes - Evaluation of degradation of coatings; Designation of quantity and size of defects, and of intensity of uniform changes in appearance; Part 5: Assessment of degree of flaking.
NEN-EN-ISO 4628-6	Paints and varnishes - Evaluation of degradation of coatings; Designation of quantity and size of defects, and of intensity of uniform changes in appearance; Part 6: Assessment of degree of chalking by tape method.
NEN-EN-ISO 6270-1	Paints and varnishes – Determination of resistance to humidity; Part 1: Continuous (single-sided exposure).
NEN-EN-ISO 6270-2	Paints and varnishes – Determination of resistance to humidity; Part 2: Condensation (in-cabinet exposure with heated water reservoir).
NEN-EN-ISO 7010	Graphical symbols - Safety colours and safety signs - Registered safety signs.
NEN-EN-ISO 8501-1	Preparation of steel substrates before application of paints and related products; Visual assessment of surface cleanliness; Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.
NEN-EN-ISO 8501-3	Preparation of steel substrates before application of paints and related products; Visual assessment of surface cleanliness; Part 3: Preparation grades of welds, cut edges and other areas with surface imperfections.
NEN-EN-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).
NEN-EN-ISO 8502-6	Preparation of steel substrates before application of paint and related products - Tests for the assessment of surface cleanliness; Part 6: Extraction of soluble contaminants for analysis - The Bresle method.
NEN-EN-ISO 8503-1	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blastcleaned steel substrates – Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces.
NEN-EN-ISO 9227	Corrosion tests in artificial atmospheres – Salt spray tests.
NEN-EN-ISO 12944-1	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 1: General introduction.
NEN-EN-ISO 12944-2	Paints and varnishes; Corrosion protection of steel structures by protective paint systems; Part 2: Classification of environments.



- NEN-EN-ISO 12944-3 Paints and varnishes; Corrosion protection of steel structures by protective paint systems; Part 3: Design considerations.
- NEN-EN-ISO 12944-4 Paints and varnishes; Corrosion protection of steel structures by protective paint systems; Part 4: Types of surface and surface preparation.
- NEN-EN-ISO 12944-5 Paints and varnishes; Corrosion protection of steel structures by protective paint systems; Part 5: Protected paint systems
- NEN-EN-ISO 12944-6 Paints and varnishes; Corrosion protection of steel structures by protective paint systems; Part 6: Laboratory performance test methods.
- NEN-EN-ISO 12944-7 Paints and varnishes; Corrosion protection of steel structures by protective paint systems; Part 7: Execution and supervision of paint work.
- NEN-EN-ISO 17025 General requirements for the competence of testing and calibration laboratories.
- NEN-EN-ISO 17652-1 Welding - Test for shop primers in relation to welding and allied processes - Part 1: General requirements
- NEN-EN-ISO 17652-2 Welding - Test for shop primers in relation to welding and allied processes - Part 2: Welding properties of shop primers.
- NEN-EN-ISO 17652-3 Welding - Test for shop primers in relation to welding and allied processes - Part 3: Thermal cutting
- NEN-EN-ISO 17652-4 Welding - Test for shop primers in relation to welding and allied processes - Part 4: Emission of fumes and gases.
- NEN-EN-ISO 19598 Metallic coatings - Electroplated coatings of zinc and zinc alloys on iron or steel with supplementary Cr(VI)-free treatment.
- NEN-EN-ISO 21809-1 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).
- NEN-EN-ISO 21809-3 Petroleum and natural gas industries - External coatings for buried or submerged pipelines used in pipeline transportation systems; Part 3: Field joint coatings.
- NEN-EN-ISO 29601 Paints and varnishes – Corrosion protection by protective paint systems – Assessment of porosity in a dry film

NEN-ISO 15741	Paints and varnishes - Friction-reduction coatings for the interior of on- and offshore steel pipelines for non-corrosive gases
NEN-ISO 19840	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Measurement of, and acceptance criteria for, the thickness of dry films on rough surfaces.
NEN-ISO 20560-1	Safety information for the content of piping systems and tanks - Part 1: Piping systems.
NEN-ISO 20560-2	Safety information for the content of piping systems and tanks - Part 2: Tanks.
RAL 841 GL	Primary standards of 196 RAL CLASSIC colours

## 2.4 Other references

Reference is made in this specification to the document mentioned in this subclause.

SSPC SP1	Solvent Cleaning
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### 3. DEFINITIONS, ABBREVIATIONS AND SYMBOLS

#### 3.1 Definitions

In this specification the following definitions are applicable:

Coating application	Pre-treatment plus the application of one or more coatings to a surface. In this specification the meaning of the expression "coating" includes the meaning of the expression "paint" as used in (the titles of) various standards.
Dew point temperature	The dew point temperature is the temperature at which air is saturated with water vapour. When the air cools down further condensation will occur.
Dry film thickness	The thickness (in microns) of the dried or cured coating film.
High Build	Coating types with a considerable coating thickness, which can be achieved in a single operation.
Sweep blasting	Blast-cleaning at reduced velocity.
Surface roughness	The roughness profile of a blast-cleaned surface.
Transport medium <sup>1</sup>	A gaseous or liquefied substance that is transported by and/or stored in a Gasunie transport network; limited to: <ul style="list-style-type: none"> <li>– natural gas;</li> <li>– hydrogen;</li> <li>– carbon dioxide;</li> <li>– nitrogen;</li> <li>– (hot) water;</li> <li>– ammonia.</li> </ul>

#### 3.2 Abbreviations

In this specification the following abbreviations are applicable:

APS	Application procedure specification
DFT	Dry film thickness
FBE	Fusion bonded epoxy
HDPE	High density polyethylene
ITP	Inspection and test plan
MFR	Melt flow rate
NPD	Nominal pipe diameter
OIT	Oxidation induction time
PE	Polyethylene
PP	Polypropylene
PPT	Pre-production trial
REACH	Registration, evaluation, authorization and restriction of chemicals

<sup>1</sup> Additives and other substances used in the medium or in the processes are therefore expressly outside the scope.

### 3.3 Symbols

In this specification the following symbols are applicable:

<u>Symbol</u>	<u>Description</u>	<u>Unit</u>
$T$	Temperature	°C
$T_g$	The glass transition temperature	°C
$R$	Radius	mm
$R_s$	Resistivity	$\Omega\text{m}^2$
$R_z$	Surface roughness	$\mu\text{m}$

#### **4. GENERAL COATING REQUIREMENTS**

The occurrence of galvanic corrosion shall be prevented. As is indicated in NEN-EN-ISO 12944-3 for aboveground constructions, corrosion can occur at an electrically conducting joint of two metals of different electrochemical potential. To prevent this kind of corrosion both metals shall be coated. When one of the metals is e.g. stainless steel, then the stainless steel shall be coated over a length of at least 15 mm from the joint.

Where underground application applies, objects shall be fully coated.

For the application of coatings, the design considerations given in NEN-EN-ISO 12944-3 shall be met, with the exception of the reference to NEN-EN-ISO 8501-3 grade P3. Minimum surface preparation P2, additional weld porosity and welding spatters shall be dressed out.

## **5. PRE-TREATMENT (SURFACE PREPARATION)**

### **5.1 Degreasing and cleaning**

Grease and oil shall be removed according to SSPC SP1 prior to blast cleaning.

### **5.2 Blast cleaning**

The blasting material shall be sharp edged (grit).  
Shot (round blasting material) is prohibited.

For stainless steel and aluminium an inert blasting material shall be used.

The grit material shall be free of grease, oil and other contaminants, such as salts. The maximum conductivity of the abrasive is 150  $\mu\text{S}/\text{cm}$ .

During blasting, it is not allowed that grit or dirt penetrate the inside of the valve or other parts of the pipeline or its appurtenances where penetration by or the presence of blasting material may cause the component to malfunction or to be damaged.

Gasket surfaces shall be protected during blast cleaning.

Item identifications, such as permanent hard stamps, shall be protected during blasting or other cleaning operations.

#### **5.2.1 Pre-treatment of galvanised surfaces**

The following applies to galvanised surfaces:  
The surface shall be free of defects such as zinc corrosion, burrs, zinc sheets. If these defects occur, they shall be removed by steam cleaning and **manual** sanding and/or filing. The surface shall be blasted lightly and evenly with a moderate pressure and a fine-grained, non-metallic blasting agent.

The result of the pre-treatment shall be an evenly roughened surface without damage or aforementioned defects. Blasting agents containing iron or copper are not allowed.

Repair of damaged hot-dip galvanised steel shall be in accordance with NEN-EN-ISO 1461.

## **6. APPLICATION OF COATINGS**

### **6.1 General requirements**

Coating application shall be done in conformance with the applicable systems described in annex A. The identification of the object to be treated (as indicated on the type plates) shall be registered.

### **6.2 Stripe coat**

As required by NEN-EN-ISO 12944-7 all critical parts such as edges, gaps, angles, weld seams, bolts and nuts shall be pre-applied with a **brush** before the specified coating layer is applied (not valid for factory-applied line pipe). This shall be done for each specified layer. The DFT on these areas shall fulfil the required DFT.

### **6.3 Sealing**

Capillary seams, blind holes and other potential points for corrosion attack arising from retention of moisture and dirt, including any abrasive used for surface preparation and which are without a safety function, shall be sealed with a durable polyurethane sealant, ensuring that the requirements of NEN-EN-ISO 12944-3 are met.

The sealant shall be placed before the last coating layer. The transitions between the sealant and steel surface shall be smooth and shall not have raised edges.

### **6.4 Application**

#### **6.4.1 Material**

Coating material shall be supplied and stored according to NEN-EN-ISO 12944-7.

#### **6.4.2 Coating thickness**

Determining the coating thickness shall be in accordance with NEN-ISO 19840.

In case a minimum and/or maximum DFT is specified (e.g. PE, PP extrusions, code U, Z) all the individually measured DFTs shall be equal to or greater than the specified minimum and equal to or less than the maximum value.

#### **6.4.3 Applying subsequent coating layers**

A clear colour difference shall be visible between the successive layers. The underlying layers may not be visible through the final layer. The colour of the top coating shall be in compliance with the requirements of clause 9.

#### **6.4.4 Application of galvanised surfaces**

Coating thickness and application of hot-dip galvanised layers shall be in accordance with NEN-EN-ISO 1461.

The coated surface shall be free of nodules, blisters, roughness and sharp points.

**6.4.5 Transition underground - aboveground coating**

The transition of code U or Z to code B shall be applied approximately 100 mm below the name plate bracket or vertical drain valve. Code U or Z shall be applied first and for a length of 10 cm, code B on top of code U or Z. The ending of code U or Z shall be smooth and sloping.

**6.4.6 Transition between various coating types**

Where there is a transition from coating types Code B, B1, U, Y, Z to PE or PP (Code J or W1), the pipe in this transition must remain uncoated over a length of 10 cm.

**6.4.7 Chamfering**

The edge of code J, U, W1, or Z with the cutback shall be chamfered; length of chamfered plane at least 8 mm.

**6.4.8 Method of application**

Paint systems shall be applied by spray application. Brush application is not allowed except for applying stripe coat. Overspray is not permitted.

**6.4.9 Repairs**

Each layer and the finished coating shall be free from dust and other contaminants, holidays, pores, runs and sags, scorching or any other defect.

Should a defect occur, the affected area shall be smaller than 10 cm<sup>2</sup> per defect. The total amount of defects in the finished coating shall not exceed three. Repairs of coating to be buried in soil shall be marked with a green circle.



## 7. UNCOATED SURFACES

The surfaces of the following parts shall not be blast cleaned and shall remain uncoated; highlighted<sup>1)</sup> sections below shall be protected with a temporary rust protection.

- gasket surfaces<sup>1)</sup>;
- greasing points<sup>1)</sup>;
- all planes of moving parts<sup>1)</sup>;
- vent plugs<sup>1)</sup>;
- spindle squares<sup>1)</sup>;
- stainless steel parts (only for aboveground application)<sup>2)</sup>;
- identification plates.

### Notes:

- 1) Protect with CMR-free tectyl.
- 2) Underground parts shall be coated but aboveground parts remain uncoated.

### 7.1 Length and coating of cutback (weld ends)

The length of the cutback shall be as follows:

#### Internally:

- |                      |                |
|----------------------|----------------|
| – pipes:             | 20 mm ± 5 mm;  |
| – valves:            | 0 mm;          |
| – bends:             | 20 mm ± 10 mm; |
| – insulating joints: | 20 mm ± 10 mm; |
| – fittings:          | 20 mm ± 10 mm; |

#### Externally:

- |                         |                 |
|-------------------------|-----------------|
| – pipes:                | 200 mm ± 10 mm; |
| – valves:               | 20 mm ± 5 mm;   |
| – bends:                | 180 mm ± 30mm;  |
| – insulating joints:    | 200 mm ± 10 mm; |
| – fitting side ≤ DN 600 | 90 mm ± 20 mm;  |
| – fitting side > DN 600 | 180 mm ± 30 mm. |

Cutback shall be coated with code A (shop primer only).

## 8. MARKING AND IDENTIFICATION OF MATERIALS

Codes marked in the steel, such as batch and pipe numbers, shall remain visible at all times after treatment. These codes shall be marked with a white frame. These marked surfaces shall be provided with temporary, removable CMR free colourless protection.

The following details shall also be marked on the coating with the use of a template:

- N.V. Nederlandse Gasunie;
- Gasunie purchase order (BB) number;
- supplier's name;
- nominal diameter (DN) x wall thickness (mm);
- length (in metres) (only for pipe);
- pipe and/or bend numbers.

The template shall be placed externally and internally (internally only above DN 600) at the ends.

If identification plates are required, these shall be fitted with epoxy glue, polyurethane coating (or similar) **after** the complete coating has been applied.

## 9. COLOUR SYSTEMS

### 9.1 Aboveground systems

The colour of aboveground steel structures, vessels and pipeline systems for natural gas (maximum operating temperature 90 °C) shall be grey, RAL 7038<sup>1)</sup>.

Exceptions:

- Structural steel on LNG: Blue RAL 5010;
- Isolation joints: Black RAL 9005;
- Identification colours: as per NEN-ISO 20560-1 &-2.

### 9.2 Underground systems

A colour coding shall be applied to pipes and (induction) bends by means of one coloured band, 50 mm - 70 mm wide at each end of the pipe or bend, at least 500 mm from the steel bevel (depending on the template size). The coating used shall be weather- and UV-resistant and shall adhere to the coating.

The following colours and marks shall be used:

steel L245ME/NE:	no band;
steel L290NE:	yellow band;
steel L360NE:	pink band;
steel L415ME:	red band;
steel L450ME:	orange band;
steel L485ME:	blue band;
QT steel	On each cutback in the 12, 4 and 8 o'clock position the marking: "QT steel"
Skelp welds:	green coloured band on the ends of the pipe;
Centre of the pipe:	black band for PP coated pipes; white band for PE coated pipes;
Repairs on coating systems buried in soil:	green circle.

1) All RAL numbers are according to RAL 841 GL.

## **10. SHIPPING, STORAGE AND TRANSPORT MATERIALS**

Coated materials shall be handled, transported and stored according to MSA-23-N (stacking height) and MSA-25-E.

## **11. VALIDATION AND VERIFICATION REQUIREMENTS**

### **11.1 Requirements for documents and information on documents**

Coating applicator shall demonstrate that the coating quality complies with what is described in the coating plan and the ITP.

### **11.2 Inspection and testing**

Coated objects shall be subjected to inspection and testing during and after the coating process. Inspection and testing shall be carried out by the coating applicator in accordance with the inspection and test plan submitted by the coating applicator and approved by all involved parties. The coating applicator shall afford the client inspector (Gasunie or subcontractor) every opportunity and facility to convince the inspector that the coating process is in accordance with the specified requirements.

A responsible person representing the supplier of goods / coating applicator shall be present during the inspection to ensure that the inspection can proceed without delay.

### **11.3 Inspection and test plan**

The coating applicator shall draw up an ITP according to the Coating Audit Questionnaire GTS\_W-024, covering all verification activities and indicating all tests/inspections to be witnessed by own employee or client (Gasunie or subcontractor). The ITP shall be validated by Gasunie prior to commencement of manufacturing. In principle, coating applicators may use their own procedure and format for the ITP, provided the minimum requirements are included.

An update of the ITP and approval by Gasunie is required either every 3 years or by any change in the coating applicator's production procedures or a new revision of this specification.

### **11.4 Test results and safety data**

Every delivery shall be completed with the following documents:

- Recorded test results according to the qualified ITP;  
an example of "Inspection report on paint and coating work; in shop application" is given on form GTS\_W-013.
- Material Safety Data Sheets for all coating substances or mixtures in Dutch language, mentioning the safety hazards (for example chromium VI) according Dutch national regulations (at section 15.1 of the Material Safety Data Sheets).

## **12. QUALIFICATION REQUIREMENTS**

To be entitled to supply coated (pressurised) equipment, pipes and/or pipeline elements to Gasunie or for usage in Gasunie projects or to apply coating commissioned by Gasunie, both coating systems and coating application shall be qualified by Gasunie.

Approvals in the qualification process of coating systems and coating applications are given by the Gasunie's coating department.

Qualification is (partly) based on the qualification schema according to NEN-EN-ISO 21809-1; the subjects coating system qualification and pre-production trial apply for Gasunie.

The approval process consists of the following steps:

### **12.1 Coating systems**

Coating systems shall meet the specific coating requirements of annex D of this MSW-11-E. This shall be demonstrated by means of an independent declaration, including test results. All approved coating systems are indicated on form GTS W-110 "Qualified coating systems"; for these approved coating systems the above mentioned independent declaration is not necessary.

### **12.2 Coating application**

- a completion by supplier of goods and approval by Gasunie of the "audit question list coating" (GTS\_W-024).
- b inspection and witnessing of the coating plant, coating application and the quality control system by Gasunie's coating department.
- c Pre-Production Trial (PPT) by the coating applicator (reviewed and witnessed by Gasunie's coating department), results shall meet the specific coating requirements of the sections C.1–C.6 (MSW-11-E).

The Application Procedure Specification and an Inspection and Test Plan are applicable to the trials and during production. The APS describes how the coating is applied (and associated items) and the ITP describes the items to be tested, the test criteria and the frequency of the tests. In general, the ITP represents the quality control plan of the coating application in accordance with the APS.

During the PPT, the tests that are done during production are done at a higher frequency: at least all tests are applied to the first three objects of the production. The tests at the PPT and during production are the same and are given in annex C. Gasunie can approve test results of tests done on objects for other users, they need not necessarily have been done on Gasunie objects.

The qualification scheme applies to permanent coatings. Temporary coatings have to prove their final objective: protection for 1 year.

The qualification has a validity of 3 years.

The order for coating application can be given by Gasunie, but also by others, such as suppliers or contractors. The ordering company has the final responsibility for the coating and the coating application. The Gasunie-approved ITP shall be used for the coating application and the activities in this ITP shall be endorsed by the coating application ordering party.

## **13. WARRANTY FOR COATING SYSTEMS**

### **13.1 Warranty obligations**

#### **13.1.1 *Warranty period***

The warranty period for coating systems, as mentioned in annex A, is five years after the delivery date except for code A, which is 1 year.

#### **13.1.2 *Corrosion***

The protective effect of the coating system shall be such that the conserved parts of the relevant object shall show no corrosion during the period mentioned in subclause 13.1.1 (Ri 0 according to NEN-EN-ISO 4628-3).

#### **13.1.3 *Detachment or flaking***

During the period mentioned in subclause 13.1.1, the coating system applied shall show no detachment from the underground layer or between the individual layers (flaking) of the coating system (NEN-EN-ISO 4628-5 class 0).

#### **13.1.4 *Blistering***

During the period mentioned in subclause 13.1.1, the coating system applied shall show no blisters (NEN-EN-ISO 4628-2 density class 0).

#### **13.1.5 *Cracks***

During the period mentioned in subclause 13.1.1, the coating system applied shall show no cracks or crackle; not in the entire coating system, nor in any one of the individual layers that are part of this (NEN-EN-ISO 4628-4 class 0).

#### **13.1.6 *Chalking***

The coating system applied (code B only) shall show no chalking larger than value 1 according to NEN-EN-ISO 4628-6 during the period mentioned in subclause 13.1.1.



## ANNEXES

### A COATING SYSTEMS

The coating systems mentioned in this annex apply to entire surfaces. For coating of welding stubs, reference is made to subclause 7.1.

For each coating system, the required coating system qualification is described in annex D. Applicator (contractor) may only use the qualified products indicated on the form GTS\_W-110 Qualified coating systems (CSW-55-N/1, CSW-55-N/2 & MSW-11-E).

#### A.1 Code A

Code A consists of 2 options: shop coating or shop primer;

##### A.1.1 Shop coating

This coating is a temporary coating for storage purposes (in open air) only. The type of coating is not prescribed; only the generic conditions that have to be fulfilled.

General conditions of the coating used; the coating:

- can be removed without creating limitations to blasting to Sa 2½;
- does not have negative implications on the performance of mill and field applied coatings. In particular, the adhesion of such mill or field coatings to the steel shall not be negatively affected.
- shall be in compliance with REACH, no chromium VI allowed;
- shall not have negative effects on the weldability of weld ends;
- shall not have negative HSE implications, not during storage, nor during removal e.g. by grit blasting, nor during welding.

When removal is not possible by grit blasting, manufacturer shall indicate the proper manner of removal of the coating. The method of removal shall be acceptable for Gasunie.

Internal coating: Before application of code A, the metal surface shall be grit blasted to Sa 2½ according NEN-EN-ISO 8501-1. Grit blasting enables the detection of slivers, scabs, laps and the like. This requirement does not apply to external coating.

##### A.1.2 Shop primer

When in subclause 7.1 "temporary coating on cutback" code A is chosen or when in annex B it is indicated that a shop primer shall be used, then the following applies:

1	One full layer (sprayed) of zinc silicate shop primer.	25 µm DFT
	Total coating thickness:	<hr/> 25 µm DFT

Shop primer shall comply with NEN-EN 1090-2 and NEN-EN-ISO 17652.

**A.2 Code B (maximum operating temperature 120 °C)**

1	One layer of epoxy mastic high build epoxy, aluminium pigmented	120 µm DFT
2	One layer of epoxy mastic high build epoxy.	120 µm DFT
3	One layer of high-gloss acrylic/polyurethane finishing coating, colour RAL 7038.	60 µm DFT
Total coating thickness:		<hr/> 300 µm DFT

Note:

- Brush application is not allowed except for applying stripe coat.

**A.3 Code B1 (insulated, maximum operating temperature 120 °C)**

1	One layer of epoxy mastic high build epoxy, aluminium pigmented	120 µm DFT
2	One layer of epoxy mastic high build epoxy	90 µm DFT
3	One layer of epoxy mastic high build epoxy	90 µm DFT
Total coating thickness:		<hr/> 300 µm DFT

**A.4 Code C paint system on galvanised steel or aluminium**

1	Sweep blasting	
2	One layer epoxy primer/ tie coat	50 µm DFT
3	One layer of epoxy mastic high build epoxy	130 µm DFT
4	One layer of high-gloss polyurethane finishing coating, colour RAL 7038.	60 µm DFT
Total coating thickness:		<hr/> 240 µm DFT

Notes:

- Hot-dip galvanised plate shall be prepared in accordance with NEN 5254 and NEN-EN-ISO 12944-4.
- Surface with thermal sprayed metal (zinc and aluminium) shall be prepared according NEN-EN-ISO 12944-4.
- On surfaces with thermal sprayed metal an additional sealer (40 µm) shall be applied which fills the metal pores, as according to NEN-EN-ISO 12944-5. The total thickness is then 240 µm.
- Brush application is not allowed except for applying stripe coat.

**A.5 Code F (thermal hot-dip galvanising)**

1	Galvanising.	NEN-EN-ISO 1461
	Coating thickness steel $\geq 6$ mm	85 µm - 150 µm
	Coating thickness steel $\geq 3$ mm < 6 mm	70 µm - 130 µm
	Steel < 3 mm	55 µm - 110 µm

**A.6 Code J (HDPE extrusion coating<sup>1)</sup>)**

- |   |   |                |
|---|---|----------------|
| 1 | Applying FBE  | min 150 µm DFT |
| 2 | Applying adhesive coating. <sup>1)</sup>  | min 150 µm DFT |
| 3 | Applying extrusion coating, both wrapping and tube extrusion being permitted. <sup>1)</sup> | See table 1    |
| 4 | Bevelling PE coating ends.  |                |
| 5 | Transition PE bevel - steel one layer of modified bitumen solution (e.g. Endolac 822.31)    |                |

**Notes:**

- The coating application shall fulfil NEN-EN-ISO 21809-1.
- Total coating thickness shall be at least in accordance with table 1.

Table 1: Coating thicknesses code J

Nominal pipe diameter	Coating thickness in mm	
	on pipe	on weld seam
DN 25 ≤ NPD ≤ DN 100	1,8	1,8
DN 100 < NPD < DN 250	2,0	1,8
DN 250 ≤ NPD < 500	2,2	2,0
DN 500 ≤ NPD < 750	2,5	2,2
NPD ≥ 750	3,0	2,5

**A.7 Code L1 (flow coating)**

- |   |                                 |                  |
|---|---------------------------------|------------------|
| 1 | One layer of epoxy flow coating | 80 µm DFT        |
|   | Total coating thickness:        | <u>80 µm DFT</u> |

**Note:**

The coating shall be applied in accordance with NEN-ISO 15741.

Between the application of internal coating in a spool piece and the evacuation (vacuum condition), which for instance is a common procedure in the factory acceptance test of an ultrasonic meter or any other pressurisation/depressurisation sequence of that spool piece, a minimum period of one week (seven days) shall be observed for curing of the coating. Brush application is not allowed except for applying stripe coat.

**A.8 Code L2 (Tectyl)**

- |   |                                       |                      |
|---|---------------------------------------|----------------------|
| 1 | One layer of Tectyl                   | min 15 µm DFT        |
|   | Total coating thickness (indicative): | <u>min 15 µm DFT</u> |

**Note:**

- Valves shall not be blast cleaned internally.

**A.9 Code Q (Nickel-plated coating)**

- |   |  |           |
|---|--|-----------|
| 1 | Electroless nickel coating NEN-EN-ISO 4527 |           |
|   | Layer thickness nominal:                   | 50 µm DFT |

Notes:

- nickel-plated coating for final inside and outside coating of ultrasonic and turbine gas meters;
- corrosion resistance 4; very severe according to annex C of NEN-EN-ISO 4527;
- uniform colour and a layer without damage;
- brown decolourisation due to dewatering is accepted;
- layer thickness determined according to B.3.3 of NEN-EN-ISO 4527;
- test plates shall be made to measure:
  - adhesion;
  - thickness;
  - porosity;
  - corrosion resistance.
- type 4 of nickel coating according to annex C, table C.2 of NEN-EN-ISO 4527.

**A.10 Code R (rubber lining)**

- |   |                          |                     |
|---|--------------------------|---------------------|
| 1 | Bonding primer           | 25 µm DFT           |
| 2 | Ebonite coating          | 3 000 µm DFT        |
| 3 | Vulcanising < 145 °C.    |                     |
|   | Total coating thickness: | <u>3 025 µm DFT</u> |

Notes:

- Flanges shall be coated internally and externally. The finish of the weld ends depends on the nominal pipe size (see MSW-06-E).
- Spark testing shall be done at 6 V/µm.

**A.11 Code U (Solvent-free two-component polyurethane coating)**

- |   |                           |                                     |
|---|---------------------------|-------------------------------------|
| 1 | One layer of polyurethane | min 1500 µm DFT<br>max 4000 µm DFT* |
|---|---------------------------|-------------------------------------|

The coating shall be applied in accordance with NEN-EN 10290.

- \* On valves locally 6 mm DFT is allowed  
(e.g. bolts, nuts, connections of seal and drain tubes)  
Brush application is not allowed except for applying stripe coat.

**A.12 Code V3 (Solvent-free epoxy with KIWA certificate)**

- |   |                               |                   |
|---|-------------------------------|-------------------|
| 1 | One layer of high solid epoxy | 500 µm DFT        |
|   | Total coating thickness:      | <u>500 µm DFT</u> |

Chemical resistance of the coating shall be checked for application.  
Brush application is not allowed except for applying stripe coat.

**A.13 Code W1 (PP extrusion coating<sup>1)</sup>)**

- |   |   |                |
|---|---|----------------|
| 1 | Applying FBE  | min 150 µm DFT |
| 2 | Applying adhesive coating. <sup>1)</sup>  | min 150 µm DFT |
| 3 | Applying extrusion coating, both wrapping and tube extrusion being permitted. <sup>1)</sup> | See table 2    |
| 4 | Bevelling PP coating ends.  |                |
| 5 | Transition PP bevel - steel one layer of modified bitumen solution (e.g. Endolac 822.31)    |                |

**Notes:**

- The coating application shall fulfil NEN-EN-ISO 21809-1.
- Total coating thickness shall be at least in accordance with table 2.

- 1) Other application methods, with or without adhesive coating, can be allowed provided qualified by Gasunie.

Table 2: Coating thicknesses Code W1

Nominal pipe diameter	(Total) Coating thickness in mm	
	on pipe	on weld seam
DN 25 ≤ DN 500	4,5	3,0
> DN 500	6,0	4,0

**A.14 Code Y (heat resistance (max. operation temp.220°C) epoxy phenolic coating)**

- |   |                          |            |
|---|--------------------------|------------|
| 1 | 2 layers of 100 µm       | 200 µm DFT |
|   | Total coating thickness: | 200 µm DFT |

**A.15 Code Z (High build solvent-free epoxy)**

- |   |  |                 |
|---|--|-----------------|
| 1 | One layer of high build solvent-free epoxy | Min 1500 µm DFT |
|   | Total coating thickness:                   | Min 1500 µm DFT |

**Notes:**

- The coating shall be applied in accordance with NEN-EN 10289.
- Brush application is not allowed except for applying stripe coat.

**A.16 Overview of coating systems at Gasunie**

An overview of all coating systems (in past and present) used within Gasunie is given in GTS\_W-111.

**B SYSTEM SELECTION TABLE**

<b>ITEM</b>	<b>External surfaces</b>	<b>Internal surfaces</b> (Only for natural gas and hydrogen <sup>8)</sup> )
Accessories	A <sup>7)</sup>	A <sup>7)</sup>
Actuators	B, C <sup>5)</sup>	-
<b>Bends (3D, 5D, 10D)</b>		
≤ DN 600 (above- and underground)	A	A <sup>7)</sup>
> DN 600 (aboveground)	B	L1
> DN 600 (underground)	U, Z	L1
Cage ladders	F	-
Caps	A <sup>7)</sup>	A <sup>7)</sup>
<b>Elbows (1,5D, 3D)</b>		
≤ DN 600 (above- and underground)	A	A <sup>7)</sup>
> DN 600 (aboveground)	B	A <sup>7)</sup>
> DN 600 (underground)	U, Z	A <sup>7)</sup>
> DN 600 prefab	A	A <sup>7)</sup>
Flanges	A	A
Flow straighteners	L2	-
Gas pressure regulators	B, C	-
Gearboxes	B	-
Insulating flanges	R	R
Insulating joints	U	L1
Liquid catchers	U, Z	-
Nipple flanges	B1	-
<b>Pipes</b>		
aboveground $T \leq 120\text{ °C}$	B	L1 <sup>6),4)</sup>
aboveground insulated $T \leq 120\text{ °C}$	B1	L1 <sup>6),4)</sup>
underground	J <sup>6)</sup> , W1 <sup>6)</sup>	L1 <sup>6),4)</sup>
$120\text{ °C} < T < 220\text{ °C}$	Y	Y
HDD, drillings, pressings	W1	L1 <sup>4)</sup>
in storage (surplus pipe)	A <sup>7)</sup>	L1 <sup>6),4)</sup>
Pipe supports aboveground	F, B	-
Pipe supports underground	F, U, Z	
Platforms	F	-
Pressure relief valve	B	-
Pressure vessels $\leq 120\text{ °C}^{1),4)}$	B1	-
Pressure vessels, insulated	B	-
Quick closing doors	B	A <sup>7)</sup>
<b>Reducers</b>		
≤ DN 600 (above- and underground)	A	A <sup>7)</sup>
> DN 600 (aboveground)	B	A <sup>7)</sup>
> DN 600 (underground)	U	A <sup>7)</sup>
> DN 600 prefab	A	A <sup>7)</sup>
Repair sleeves	A	A
Right-angled transmissions	U, Z	-
Scraper traps	B	L1
Skids	F+C	-
Spindles	U, Z	-
Spindles hollow	U, Z	L2

ITEM	External surfaces	Internal surfaces (Only for natural gas and hydrogen <sup>8)</sup> )
Spool pieces	B	L1 <sup>4)</sup>
Stairs	F	-
Static mixers	U, Z	L2
Steel structures with colour	F+C	-
Steel structures without colour	F	-
Storage tanks aboveground	B	V3 <sup>2)</sup>
Storage tanks underground	Z <sup>2)</sup>	V3 <sup>2)</sup>
Stud bolts, bolts, nuts, washers	<sup>3)</sup>	-
Syphons	U, Z	-
<b>Tees</b>		
≤ DN 600 (above- and underground)	A	A <sup>7)</sup>
> DN 600 (aboveground)	B	A <sup>7)</sup>
> DN 600 (underground)	U	A <sup>7)</sup>
> DN 600 prefab	A	A <sup>7)</sup>
Stopples and splittees	A	A
Ultrasonic gas meters	B	Q
20" Turbine ANSI 600 gas meters	Q	Q
Turbine gas meters	B	L1
Valves aboveground (including spindle extensions)	B	L2
Valves underground (including spindle extensions)	U, Z	L2
Extension casings	A <sup>7)</sup>	A <sup>7)</sup>

**Notes:**

1. Dust filters, heat exchangers, filter separators, scrubbers, cyclones or similar objects.
2. The application shall comply with KIWA directives BRL-K790, BRL-K768 and BRL-K779. Testing shall be done in conformance with the requirements for KIWA certification. The coating shall have KIWA approval. The supplier shall have application process certificate BRL-K790.
3. Passivated according to NEN-EN-ISO 19598 Fe/ZnNi8/Cn/TO.
4. Not required for < DN 100 and if application is infeasible.
5. For galvanised or aluminium, use code C.
6. Maximum temperature for code J, L1 is 80 °C and for code W1 110 °C.
7. For A shop coating shall be applied, for A<sup>7)</sup> shop primer shall be applied.
8. For medium other than natural gas and hydrogen contact Gasunie department "Mechanical Engineering, Technical Integrity" for determination of internal coating.

Where options are given in the table above, the party who received the Gasunie order for supply of items is responsible for making a proper choice regarding coating systems. This party also bears responsibility for the warranty obligations mentioned in this specification.

## C PPT & PRODUCTION TESTS FOR COATING SYSTEMS

The following clauses contain the tests, test methods and Gasunie requirements. The results from the tests shall be reported in writing. Where possible, test results shall be reported with numerical values; pass/fail report results shall be avoided.

### Specific per coating code

#### C.1 PPT & production tests for 3 layer PE coating (code J)

PPT & production tests to be performed and reported	Test method according to:	Gasunie requirements
Humidity (air)	n/a	< 80 %
Temperature (air)	n/a	5 °C < T < 35 °C
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	> 3 °C
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	< 20 mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	R <sub>z</sub> 50 µm - 100 µm
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating ≤ rate 2
Preheating temperature before application	Monitored T	according to data sheet
Temperature after cooling	Monitored T	max 80 °C
Epoxy thickness	NEN-ISO 19840	According to this specification (MSW-11-E)
Minimum adhesive thickness	NEN-ISO 19840	According to this specification (MSW-11-E)
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Impact resistance	NEN-EN-ISO 21809-1	> 7 J per mm coating thickness.
Peel strength	NEN-EN-ISO 21809-1	≥ 15 N/mm at 23 °C and ≥ 3 N/mm at 80 °C
Indentation	NEN-EN-ISO 21809-1	≤ 0,2 mm at 23 °C and ≤ 0,4 mm at 80 °C
Elongation at break	NEN-EN-ISO 21809-1	≥ 400 %



<b>PPT &amp; production tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Holiday detection	NEN-EN-ISO 21809-1	Test voltage 25 kV, no holidays
Cd test	NEN-EN-ISO 21809-1	23 °C/28 d -1,5 V $R \leq 5$ mm 65 °C/24 h -3,5 V $R \leq 4$ mm
Glass transition temperature epoxy	NEN-EN-ISO 21809-1	$-3\text{ °C} < \Delta T_g < 3\text{ °C}$
Product stability of PE ( $\Delta$ MFR between compound and extruded film) <sup>1)</sup>	NEN-EN-ISO 21809-1	$\Delta$ MFR $\leq 20\%$

<sup>1)</sup> When  $\Delta$ MFR is not relevant, than an OIT test shall be done according to NEN-EN-ISO 21809-3.

**C.2 PPT & production tests for 3 layer PP coating (code W1)**

<b>PPT &amp; production tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Humidity (air)	n/a	< 80 %
Temperature (air)	n/a	5 °C < T < 35 °C
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	> 3 °C
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	< 20 mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	R <sub>z</sub> 50 µm - 100 µm
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating ≤ rate 2
Preheating temperature before application	Monitored T	according to data sheet
Temperature after cooling	Monitored T	max 80 °C
Epoxy thickness	NEN-ISO 19840	According to this specification (MSW-11-E)
Minimum adhesive thickness	NEN-ISO 19840	According to this specification (MSW-11-E)
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Impact resistance	NEN-EN-ISO 21809-1	> 10 J per mm coating thickness
Peel strength	NEN-EN-ISO 21809-1	≥ 25 N/mm at 23 °C and ≥ 4 N/mm at 90 °C
Indentation	NEN-EN-ISO 21809-1	≤ 0,1 mm at 23 °C and ≤ 0,4 mm at 110 °C
Elongation at break	NEN-EN-ISO 21809-1	≥ 400 %
Holiday detection	NEN-EN-ISO 21809-1	Test voltage 25 kV, no holidays
Cd test	NEN-EN-ISO 21809-1	23 °C/28 d -1,5 V R ≤ 5 mm 65 °C/24 h -3,5 V R ≤ 4 mm
Glass transition temperature epoxy	NEN-EN-ISO 21809-1	-3 °C < $\Delta T_g$ < 3 °C

<b>PPT &amp; production tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Product stability of PP ( $\Delta$ MFR between compound and extruded film) <sup>1)</sup>	NEN-EN-ISO 21809-1	$\Delta$ MFR $\leq$ 35 %

- 1) When  $\Delta$ MFR is not relevant, than an OIT test shall be done according to NEN-EN-ISO 21809-3.

**C.3 PPT & production tests for polyurethane coatings (code U)**

<b>PPT &amp; production tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Humidity (air)	n/a	< 80 %
Temperature (air)	n/a	5 °C < T < 35 °C
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	> 3 °C
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	< 20 mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	R <sub>z</sub> 50 µm - 120 µm
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating ≤ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Impact resistance	NEN-EN 10290	7 J per mm coating thickness at 23 °C and no holidays
Adhesion Pull Off method	NEN-EN-ISO 4624	>10 MPa (curing time according to manufacturer's specifications)
Hardness test shore D	NEN-EN 10290	manufacturer's specification
Holiday detection	NEN-EN 10290	Test voltage 20 kV, no holidays
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Visual assessment	NEN-EN 10290	Uniform colour, smooth appearance, maximum of 4 coating repairs per object

**C.4 PPT & production tests for flow coating (code L1)**

<b>PPT &amp; production tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Humidity (air)	n/a	< 80 %
Temperature (air)	n/a	5 °C < T < 35 °C
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	> 3 °C
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides on steel surface after blasting	NEN-EN-ISO 8502-6	< 20 mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	R <sub>z</sub> 25 µm - 60 µm
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating ≤ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback internal (length)	n/a	According to this specification (MSW-11-E)
Bendability	NEN-ISO 15741	No cracking
Cross cut test	NEN-ISO 15741	Class ≤ 1
Hardness test	NEN-ISO 15741	≥ 94 Buchholz
Pinhole test	NEN-ISO 15741	Max one pinhole per day
Low voltage holiday detection (if pinhole test fails)	NEN-ISO 15741	One pinhole per 100 cm <sup>2</sup> tested at at least 10 areas, excluding welds
Curing test	NEN-ISO 15741	No blistering, softening or wrinkling

**C.5 PPT & production tests for High solid epoxy coatings (code Z)**

<b>PPT &amp; production tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Humidity (air)	n/a	< 80 %
Temperature (air)	n/a	5 °C < T < 35 °C
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	> 3 °C
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	< 20 mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	R <sub>z</sub> 75 µm - 150 µm
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating ≤ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Impact resistance	NEN-EN 10289	5 J per mm coating thickness at 23 °C and no holidays
Adhesion Pull Off method	NEN-EN-ISO 4624	> 7,5 MPa (curing time according to manufacturer's specifications)
Holiday detection	NEN-EN 10289	5 kV per mm DFT no holidays
Hardness Shore D	NEN-EN 10289	manufacturer's specification
Visual assessment	n/a	maximum of 4 coating repairs per object

**C.6 PPT & production tests for paint systems (codes B, C)**

<b>PPT &amp; production tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Humidity (air)	n/a	< 80 %
Temperature (air)	n/a	5 °C < T < 35 °C
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	> 3 °C
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides	NEN-EN-ISO 8502-6	< 20 mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	R <sub>z</sub> 50 µm - 100 µm
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	Code B at least C Sa 2½, Code C sweep blasted
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating ≤ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Film thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Stripe coat applied on all critical parts	n/a	According to this specification (MSW-11-E)
Visual assessment	NEN-EN-ISO 12944-7	No sags, runs and the like, fulfilling NEN-EN-ISO standard.
Adhesion test, Pull Off test	NEN-EN-ISO 4624	≥ 8 MPa (curing time according to manufacturer's specifications)
Low voltage holiday detection	NEN-EN-ISO 29601	No holidays

## D COATING SYSTEM TESTS, SPECIFIC PER COATING CODE

### D.1 Coating system tests for 3 layer PE coating (code J)

In general the requirements of NEN-EN-ISO 21809-1 shall be met and in particular:

Coating system tests to be performed and reported	Test method according to:	Gasunie requirements
Cathodic disbonding	NEN-EN-ISO 21809-1	23 °C/28 d -1,5 V $R \leq 5$ mm 65 °C/24 h -3,5 V $R \leq 4$ mm
Peel strength	NEN-EN-ISO 21809-1	$\geq 15$ N/mm at 23 °C and $\geq 3$ N/mm at 80 °C
Elongation at break	NEN-EN-ISO 21809-1	$\geq 400$ %
Impact resistance	NEN-EN-ISO 21809-1	$> 7$ J per mm coating thickness.
Indentation	NEN-EN-ISO 21809-1	$\leq 0,2$ mm at 23 °C and $\leq 0,4$ mm at 80 °C
Flexibility at (0 °C and 2° per pipe diameter length)	NEN-EN-ISO 21809-1	No cracks or holidays
Heat aging	NEN-EN-ISO 21809-1	$\Delta MFR \leq 35$ %
UV aging	NEN-EN-ISO 21809-1	$\Delta MFR \leq 35\%$
Coating Resistivity	DIN 30670	$R_s > 10^8 \Omega m^2$
Humidity (air)	n/a	$< 80$ %
Temperature (air)	n/a	$5^\circ C < T < 35^\circ C$
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	$> 3^\circ C$
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	$< 20$ mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	$R_z$ 50 $\mu m$ - 100 $\mu m$
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating $\leq$ rate 2
Preheating temperature before application	Monitored $T$	according to data sheet
Temperature after cooling	Monitored $T$	max 80 °C
Epoxy thickness	NEN-ISO 19840	According to this specification (MSW-11-E)



<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Minimum adhesive thickness	NEN-ISO 19840	According to this specification (MSW-11-E)
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Holiday detection	NEN-EN-ISO 21809-1	Test voltage 25 kV, no holidays
Glass transition temperature epoxy	NEN-EN-ISO 21809-1	$-3\text{ }^{\circ}\text{C} < \Delta T_g < 3\text{ }^{\circ}\text{C}$
Product stability of PE ( $\Delta\text{MFR}$ between compound and extruded film) <sup>1)</sup>	NEN-EN-ISO 21809-1	$\Delta\text{MFR} \leq 20\%$
Chromium VI analysis on FBE coating	NEN-EN-ISO 17025 <sup>2)</sup>	Coating system shall be free of chromium VI

<sup>1)</sup> When  $\Delta\text{MFR}$  is not relevant, than an OIT test shall be done according to NEN-EN-ISO 21809-3.

<sup>2)</sup> The accreditation shall cover the determination of chromium VI in paint samples.

**D.2 Coating system tests for 3 layer PP coating (code W1)**

In general the requirements of NEN-EN-ISO 21809-1 shall be met and in particular:

<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Cathodic disbonding	NEN-EN-ISO 21809-1	23 °C/28 d - 1,5 V R ≤ 5 mm 65 °C/24 h - 3,5 V R ≤ 4 mm
Peel strength	NEN-EN-ISO 21809-1	≥ 25 N/mm at 23 °C and ≥ 4 N/mm at 90 °C
Elongation at break	NEN-EN-ISO 21809-1	≥ 400 %
Impact resistance	NEN-EN-ISO 21809-1	> 10 J per mm coating thickness.
Indentation	NEN-EN-ISO 21809-1	≤ 0,1 mm at 23 °C and ≤ 0,4 mm at 110 °C
Flexibility at (0 °C and 2° per pipe diameter length)	NEN-EN-ISO 21809-1	No cracks or holidays
Heat aging	NEN-EN-ISO 21809-1	ΔMFR ≤ 35 %
UV aging	NEN-EN-ISO 21809-1	ΔMFR ≤ 35 %
Coating resistivity	DIN 30678	$R_s > 10^8 \Omega m^2$
Humidity (air)	n/a	< 80 %
Temperature (air)	n/a	5 °C < T < 35 °C
ΔT surface to be coated at least 3 °C above dew point	n/a	> 3 °C
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	< 20 mg/m <sup>2</sup>
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	R <sub>z</sub> 50 μm - 100 μm
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating ≤ rate 2
Preheating temperature before application	Monitored T	according to data sheet
Temperature after cooling	Monitored T	maximal 80 °C
Epoxy thickness	NEN-ISO 19840	According to this specification (MSW-11-E)
Minimum adhesive thickness	NEN-ISO 19840	According to this specification (MSW-11-E)
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)

<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Holiday detection	NEN-EN-ISO 21809-1	Test voltage 25 kV no holidays
Glass transition temperature epoxy	NEN-EN-ISO 21809-1	$-3\text{ }^{\circ}\text{C} < \Delta T_g < 3\text{ }^{\circ}\text{C}$
Product stability of PP ( $\Delta\text{MFR}$ between compound and extruded film) <sup>1)</sup>	NEN-EN-ISO 21809-1	$\Delta\text{MFR} \leq 35\%$
Chromium VI analysis on FBE coating	NEN-EN-ISO 17025 <sup>2)</sup>	Coating system shall be free of chromium VI

<sup>1)</sup> When  $\Delta\text{MFR}$  is not relevant, than an OIT test shall be done according to NEN-EN-ISO 21809-3.

<sup>2)</sup> The accreditation shall cover the determination of chromium VI in paint samples.

**D.3 Coating system tests for polyurethane coatings (code U)**

<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Cathodic disbonding	NEN-EN 10290	23 °C/28 d - 1,5 V $R \leq 6$ mm 60 °C/48 h -1,5 V $R \leq 6$ mm
Adhesion test Pull Off method	NEN-EN 10290	$\geq 10$ MPa at 23 °C
Indentation	NEN-EN 10290	$\leq 0,2$ mm at 23 °C and $\leq 0,3 \cdot \text{DFT}$ at 80 °C
Flexibility at 0 °C $\pm 2$ °C and 23 °C $\pm 2$ °C	NEN-EN 10290	No cracks or holidays
Water absorption test	NEN-EN 10290	100 h/80 °C no loss of adhesion or $\leq 3$ mm (to steel)
Heat aging	NEN-EN 10290	100 d/80 °C 8 MPa (to steel)
Elongation at break	NEN-EN 10290	$\geq 10$ %
Coating resistivity	NEN-EN 10290	$R_s > 10^7 \Omega \text{m}^2$
Humidity (air)	n/a	$< 80$ %
Temperature (air)	n/a	$5^\circ \text{C} < T < 35^\circ \text{C}$
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	$> 3^\circ \text{C}$
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	$< 20 \text{ mg/m}^2$
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	$R_z$ 50 $\mu\text{m}$ - 120 $\mu\text{m}$
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating $\leq$ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Impact resistance	NEN-EN 10290	7 J per mm coating thickness at 23 °C and no holidays
Hardness test shore D	NEN-EN 10290	manufacturer's specification
Holiday detection	NEN-EN 10290	Test voltage 20 kV, no holidays
Chromium VI analysis on polyurethane coating	NEN-EN-ISO 17025 <sup>1)</sup>	Coating system shall be free of chromium VI

<sup>1)</sup> The accreditation shall cover the determination of chromium VI in paint samples.

**D.4 Coating system tests for flow coating (code L1)**

In general the requirements of NEN-ISO 15741 shall be met and in particular:

<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Adhesion test	NEN-ISO 15741	Class $\leq 1$
Hardness Buchholz	NEN-ISO 15741	Minimum 94
Bendability	NEN-ISO 15741	No cracking
Water immersion	NEN-ISO 15741	No blistering, softening or wrinkling, no loss of adhesion
Salt spray test	NEN-ISO 15741	Corrosion max. 2 mm from scratch
Hydraulic blistering	NEN-ISO 15741	No blistering
Gas blistering	NEN-ISO 15741	No blistering
Humidity (air)	n/a	$< 80 \%$
Temperature (air)	n/a	$5^{\circ}\text{C} < T < 35^{\circ}\text{C}$
$\Delta T$ surface to be coated at least $3^{\circ}\text{C}$ above dew point	n/a	$> 3^{\circ}\text{C}$
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides on steel surface after blasting	NEN-EN-ISO 8502-6	$< 20 \text{ mg/m}^2$
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	$R_z 25 \mu\text{m} - 60 \mu\text{m}$
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating $\leq$ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback internal (length)	n/a	According to this specification (MSW-11-E)
Pinhole test	NEN-ISO 15741	Max one pinhole per day
Low voltage holiday detection (if pinhole test fails)	NEN-ISO 15741	One pinhole per $100 \text{ cm}^2$ tested at at least 10 areas, excluding welds
Curing test	NEN-ISO 15741	No blistering, softening or wrinkling
Chromium VI analysis on flow coating	NEN-EN-ISO 17025 <sup>1)</sup>	Coating system shall be free of chromium VI

<sup>1)</sup> The accreditation shall cover the determination of chromium VI in paint samples.

**D.5 Coating system tests for high solid epoxy coatings (code Z)**

<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Cathodic disbonding	NEN-EN 10289	23 °C/28 d - 1,5 V $R \leq 6$ mm 60 °C/48 h -1,5 V $R \leq 6$ mm
Adhesion test (Pull Off)	NEN-EN 10289	$\geq 7,5$ MPa at 23 °C and $\geq 6$ MPa at 80 °C
Impact resistance	NEN-EN 10289	$> 5$ J per mm coating thickness at 23 °C and no holidays
Indentation	NEN-EN 10289	$\leq 0,2$ mm at 23 °C and $\leq 0,3 \cdot \text{DFT}$ per mm at 80 °C
Water absorption test	NEN-EN 10289	100 h/80 °C no loss of adhesion or $\leq 3$ mm
Heat aging	NEN-EN 10289	100 d/80 °C 8 MPa
Elongation at break	NEN-EN-ISO 527-1 u/i -5	$\geq 1,7$ %
Coating resistivity	NEN-EN 10289	$R_s > 10^7 \Omega \text{m}^2$
Humidity (air)	n/a	$< 80$ %
Temperature (air)	n/a	$5^\circ \text{C} < T < 35^\circ \text{C}$
$\Delta T$ surface to be coated at least 3 °C above dew point	n/a	$> 3^\circ \text{C}$
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides contamination after blasting	NEN-EN-ISO 8502-6	$< 20 \text{ mg/m}^2$
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	$R_z 50 \mu\text{m} - 100 \mu\text{m}$
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating $\leq$ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Total coating thickness (DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Inspection cutback external (length and chamfering)	n/a	According to this specification (MSW-11-E)
Holiday detection	NEN-EN 10289	5 kV per mm DFT no holidays
Hardness (Shore D)	NEN-EN 10289	manufacturer's specification
Chromium VI analysis on solid epoxy coating	NEN-EN-ISO 17025 <sup>1)</sup>	Coating system shall be free of chromium VI

<sup>1)</sup> The accreditation shall cover the determination of chromium VI in paint samples.

**D.6 Coating system tests for paint systems (codes B, C)**

Paint systems shall comply with C5H according NEN-EN-ISO 12944-1 and NEN-EN-ISO 12944-2.

<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Determination of resistance to neutral salt spray (fog)	NEN-EN-ISO 9227 (1440 h)	Corrosion from scribe $\leq 1,5$ mm NEN-EN-ISO 4628-2 Blistering 0 (S0) NEN-EN-ISO 4628-3 Rusting Ri (0) NEN-EN-ISO 4628-4 Cracking 0 (S0) NEN-EN-ISO 4628-5 Flaking 0 (S0) NEN-EN-ISO 2409 Class 0 or 1; NEN-EN-ISO 4624 Pull Off test $\geq 5$ MPa (No adhesive break)
Determination of resistance to humidity	NEN-EN-ISO 6270-1 & -2 (720 h)	NEN-EN-ISO 4628-2 Blistering 0 (S0) NEN-EN-ISO 4628-3 Rusting Ri (0) NEN-EN-ISO 4628-4 Cracking 0 (S0) NEN-EN-ISO 4628-5 Flaking 0 (S0) NEN-EN-ISO 2409 Class 0 or 1; NEN-EN-ISO 4624 Pull Off test $\geq 5$ MPa (No adhesive break)
Cyclic ageing test	NEN-EN-ISO 12944-6 (1680 h)	Corrosion from scribe $\leq 3$ mm NEN-EN-ISO 4628-2 Blistering 0 (S0) NEN-EN-ISO 4628-3 Rusting Ri (0) NEN-EN-ISO 4628-4 Cracking 0 (S0) NEN-EN-ISO 4628-5 Flaking 0 (S0) NEN-EN-ISO 2409 Class 0 or 1; NEN-EN-ISO 4624 Pull Off test $\geq 5$ MPa (No adhesive break)
Humidity (air)	n/a	$< 80$ %
Temperature (air)	n/a	$5\text{ }^{\circ}\text{C} < T < 35\text{ }^{\circ}\text{C}$
$\Delta T$ surface to be coated at least $3\text{ }^{\circ}\text{C}$ above dew point	n/a	$> 3\text{ }^{\circ}\text{C}$
Abrasive free from oil and grease	Practical test. Abrasive in pure water for 5 minutes	Visual: no grease/oil contamination
Water soluble salt and chlorides	NEN-EN-ISO 8502-6	$< 20\text{ mg/m}^2$
Surface roughness of blasted steel	NEN-EN-ISO 8503-1	$R_z\ 50\text{ }\mu\text{m} - 100\text{ }\mu\text{m}$
Visual inspection of cleanliness blasted surface	NEN-EN-ISO 8501-1	At least C Sa 2½
Presence of dust after dust removal	NEN-EN-ISO 8502-3	Class and rating $\leq$ rate 2
Elapsed time between blasting and coating	n/a	At least C Sa 2½ shall be guaranteed
Film thickness(DFT)	NEN-ISO 19840	According to this specification (MSW-11-E)
Stripe coat applied on all critical parts	n/a	According to this specification (MSW-11-E)

<b>Coating system tests to be performed and reported</b>	<b>Test method according to:</b>	<b>Gasunie requirements</b>
Visual assessment	NEN-EN-ISO 12944-7	No sags, runs and the like, fulfilling NEN-EN-ISO standard
Adhesion test, Pull Off test	NEN-EN-ISO 4624	$\geq 8$ MPa
Low voltage holiday detection	NEN-EN-ISO 29601	No holidays
Chromium VI analysis on epoxy/Pu coatingsystem	NEN-EN-ISO 17025 <sup>1)</sup>	Coating system shall be free of chromium VI

<sup>1)</sup> The accreditation shall cover the determination of chromium VI in paint samples.