TECHNICAL SPECIFICATION

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Non-destructive testing — Discontinuities in specimens for use in qualification examinations

Essais non destructifs — Discontinuités dans les échantillons d'essai utilisés pour les examens de qualification

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Foreword

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ISO/TS 22809 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 7, *Personnel qualification*.

Non-destructive testing — Discontinuities in specimens for use in qualification examinations

1 Scope

This Technical Specification has been established to consider and define types of discontinuities to be exhibited in test specimens for use in non-destructive testing examinations.

Acoustic emission testing, infrared thermography testing, strain testing and leak testing need not define discontinuity type, due to their specific approach (e.g. replaced in AT by artificial sources).

2 Normative references

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

ISO 9712:2005, *Non-destructive testing — Qualification and certification of personnel*

ISO 4063, *Welding and allied processes — Nomenclature of processes and reference numbers*

ISO 6520-1, *Welding and allied processes — Classification of geometric imperfections in metallic materials Part 1: Fusion welding*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9712 as well as the following apply.

3.1
test area
area of a specimen, either the whole or just a portion, which is to be tested by a candidate during the practical examination

NOTE A single test specimen can contain a number of test areas with no overlap.

4 Specimens

The minimum number of specimens, n_{min}, to be held at any examination centre is calculated using the following formula:

minimum number of specimens: $n_{min} = n_{sp} \times n_{cmax}$

where

n_{sp} is the number of specimens in practical examination;

n_{cmax} is the maximum number of candidates allowed to simultaneously attempt the practical exam.

5 Product sectors

5.1 General

Specimens shall be sector-specific, simulating field geometries and containing discontinuities representative of those likely to occur during manufacturing or in service (inherent, processing and in-service discontinuities). Discontinuities may be natural, artificial or implanted. For RT, the specimens need not contain discontinuities, since these will be exhibited in the radiographs for Level 2 interpretation.

5.2 Castings (c)

5.2.1 Configuration

The range of specimens held by the examination centre can include:

— cylindrical section (large and small diameters);

— flanges;

— changes of section;

— nozzles or junctions (T, L, Y and X).

5.2.2 Types of discontinuity

Discontinuities are described in Annex A. Castings may also contain weld repairs with associated discontinuities.

5.3 Welded test specimens (w)

5.3.1 Configuration

The range of specimens held by the examination centre can include a variation of weld preparations (e.g. full/partial penetration, single/double “V”, etc.) and processes (e.g., MIG, SMAW, TIG, etc.) in:

— plate butt welds;

— tubes and pipes;

— joints (e.g., T, K, Y, X, etc.);

— nozzle and node welds;

— weld build-ups.

5.3.2 Types of discontinuity

These are described in Annex B.

5.4 Wrought test specimen (wp)

5.4.1 Configuration

The range of specimens held by the examination centre can include:

— plates and strips;

— tubes and pipes;

— long products (bars, etc.).

5.4.2 Types of discontinuity

These are described in Annex C.

5.5 Forgings (f)

5.5.1 Configuration

The range of specimens held by the examination centre can include:

— complex forgings;

— cylindrical section (large and small diameters);

— flanges;

— changes of section;

— nozzles or nodes (T, L, Y and X).

5.5.2 Types of discontinuity

These are described in Annex D.

5.6 Tubes and pipes (t)

5.6.1 Configuration

The range of specimens (seamless and welded) held by the examination centre can include:

— large and small diameters, thin and thick wall;

— nozzles or junctions (T, L, Y and X);

— elbows;

— reducers;

— flanges.

5.6.2 Types of discontinuity

These are described in Annex E.

6 Minimum size of discontinuity

6.1 General

6.1.1 If available, reporting threshold values given in NDT or product standards shall be applied. Where there are no available NDT or product standards, or no size is given in such standards, the sizes given in 6.2 to 6.6 shall be used.

6.1.2 The minimum longitudinal dimension of any mandatory reportable single discontinuity or group of small discontinuities in a specimen shall be at or above the reporting threshold size. This threshold size shall be appropriate to the inspection method and test sensitivity employed by the examination centre in the preparation of its specimen master reports.

6.1.3 The minimum through-wall dimension of any mandatory reportable discontinuity in an examination specimen for volumetric NDT methods shall be 2 mm, or 20 % of wall thickness (whichever is the lesser).

6.2 Radiographic testing (RT)

6.2.1 The practical radiography test specimen need not contain any discontinuities.

6.2.2 For discontinuities to be reported during interpretation of radiographs, the following discontinuity sizes may be considered as mandatory reportable.

— Planar discontinuities:

  — minimum length $\geqslant$ 5 mm.

— Volumetric discontinuities:

  — pores: $\geqslant$ 2 mm;

  — clusters: $\geqslant$ 5 mm;

  — inclusions: $\geqslant$ 3 mm.

6.3 Ultrasonic testing (UT)

— Planar discontinuities:

  — length: $\geqslant$ 5 mm;

  — through wall extent: $\geqslant$ 2 mm (or 20 % of wall thickness, whichever is the lesser);

  — discontinuities that exceed response from a flat bottomed hole of 2 mm diameter;

  — discontinuities that result in $\geqslant$ 50 % of back wall echo.

— Volumetric discontinuities:

  — side drill hole of 3 mm diameter (calibration level);

  — natural or other form or artificial discontinuities: $\geqslant$ 5 mm.

Where no product standard defines the maximum acceptable size of discontinuity, it is recommended to make mandatory reportable any configuration of discontinuity for which the local signal-to-noise ratio exceeds 4:1.

6.4 Magnetic particle (MT) and liquid penetrant testing (PT)

— Linear discontinuities:

  — length: $\geqslant$ 3 mm.

— Rounded discontinuities:

  — isolated: $\geqslant$ 5 mm;

  — clusters of smaller discontinuities: $\geqslant$ 5 mm.

6.5 Eddy current testing (ET)

Linear discontinuity: length: $\geqslant$ 2 mm.

Where no product standard defines the minimum size of discontinuities, it is recommended to use any configuration of discontinuity for which the local signal-to-noise ratio exceeds 4:1.

6.6 Visual testing (VT)

— direct aided VT: length of surface discontinuity: $\geqslant$ 1 mm;

— remote VT: length of surface discontinuity: $\geqslant$ 1 mm.

7 Surface conditions

The inspection access area of the specimen shall have a surface free from dirt, oil, loose products of corrosion, surface roughness, protective coatings, etc., that could interfere with the application of the NDT methods to be used.

8 Number of discontinuities

The number of reportable discontinuities contained within the specimens presented to the candidate during the examination should be such that it adequately demonstrates the competence of the candidate in detection and characterization of discontinuities. The recommended minimum number of reportable discontinuities in the total specimens presented to the candidate is four for product sectors and six for industry sectors.

9 Radiographic interpretation practical examination (radiographs)

9.1 Introduction

A radiographic interpretation practical examination requires the evaluation of radiographs (original or copy) that exhibit a sufficient range of artefacts or material/structural anomalies and densities, so as to provide a valid assessment of the competence of the candidate to properly read, correctly interpret and accurately report the results.

9.2 Conditions

9.2.1 Radiographs shall be in good condition for viewing (verified and attested by an examiner before the beginning of each examination) and shall contain at least one mandatory reportable discontinuity, but not more than five different types of discontinuity. Radiographs may be of any size, providing a suitable film viewer is available for use by candidates during the examination.

9.2.2 The use of radiographic copies or digitally reproduced equivalents is acceptable if the quality is maintained with respect to density, contrast, definition and sensitivity of the original radiographs.

9.2.3 An authorized examination centre shall hold radiographs that are representative of the product sectors for which the centre is authorized to deliver radiographic interpretation examinations. For the in-service inspection industrial sector, the range of radiographs shall include welds (w), including tubes and pipes, and castings (c).

9.3 Quality

9.3.1 Radiographs shall be produced in accordance with an appropriate standard and also with respect to proper exposure parameters, processing conditions and resulting density range.

9.3.2 In general, internationally acceptable image-quality indicators should be visible on the radiographs. In cases where the candidate is assessing the quality of the radiograph only, independent of the specimen, image-quality indicators need not be visible on the radiograph.

9.3.3 To facilitate unambiguous reporting of discontinuities and location by a candidate, radiographs shall contain not less than two reference or datum points.

10 Specimen master report

All the discontinuities in the test specimens, which could be relevant for the evaluation, shall be reported on a specimen master report, which should comply with Annex B of ISO 9712:2005.

The use of sketches to enhance information is allowed. Sketches may be scaled, depending on the acceptance level of discontinuities and candidate's qualification level.

Annex A
(informative)

Discontinuities in castings

Table A.1 — Discontinuities in castings

Material	Manufacturing process	Planar discontinuities				Volumetric discontinuities			
		Methods	Surface	Methods	Sub-surface	Methods	Surface	Methods	Sub-surface
Ferrous materials	Sand castings; Investment castings.	MT; PT; ET; RT; UT; VT.	Cracks; Hot tears; Inserts; Cold shuts; Shrinkage.	UT; RT.	Cracks; Inserts; Cold shuts; Shrinkage.	MT; PT; RT; UT; VT.	Porosity; Sink; Collapsed core; Gas cavity; Inclusions.	UT; RT.	Collapsed core; Gas cavity; Inclusions; Inserts; Shrinkage.
Non-ferritic and austenitic materials	Sand castings; Investment castings; Die castings; Pressure die castings.	PT; ET; RT; UT; VT.	Cracks; Hot tears; Inserts; Cold shuts; Shrinkage.	UT; RT.	Cracks; Inserts; Cold shuts; Shrinkage.	PT; RT; UT; VT.	Porosity; Sink; Collapsed core; Gas cavity; Inclusions.	UT; RT.	Collapsed core; Gas cavity; Inclusions; Inserts; Shrinkage.

Annex B
(informative)

Discontinuities in welds

Table B.1 — Discontinuities in welds

Type of weld [a]	Welding process [c]	Planar discontinuities				Volumetric discontinuities			
		Methods	Surface	Methods	Sub-surface	Methods	Surface	Methods	Sub-surface
Plate: Inline butt; Tee butt [b]; Cruciform. Thick to thin weld transitions; Welds with backing plates. Tube and pipe: Circumferential butt; Axial butt; Thick to thin weld transitions; Welds with backing plates; Nozzle; Node.	MIG (131) [d] MAG (135) [d] TIG (141) [d] MMA (111) [d] SAW (121) [d]	MT; PT; ET; RT; UT; VT.	Cracks (100) [e]; Lack of fusion (401) [e]; Incomplete penetration (402) [e].	RT; UT.	Cracks (100) [e]; Lack of fusion (401) [e]; Incomplete penetration (402) [e].	MT; PT; RT; UT; VT.	Porosity (200) [e]; Imperfect shape, including undercut (500) [e].	RT; UT.	Porosity (200) [e]; Inclusions (300) [e].

[a] Valuable for all materials except where MT is impossible to apply.

[b] Full and partial penetration.

[c] Other processes may be included.

[d] See ISO 4063.

[e] See ISO 6520-1.

Annex C
(informative)

Discontinuities in wrought products

Table C.1 — Discontinuities in wrought products

Material	Manufacturing process	Planar discontinuities				Volumetric discontinuities			
		Methods	Surface	Methods	Sub-surface	Methods	Surface	Methods	Sub-surface
Ferritic steels	Hot rolling; Cold rolling; Extruding; Drawing.	MT; PT; ET; UT; VT.	Cracks; Pitting; Indentations and grooves; Scratches; Laminations (flat products); Piping (bars); Seams; Stringers.	UT.	Cracks; Laminations; Piping; Inclusions (stringers).	UT; VT.	Rolled-in scale; Inclusions [a].	UT.	Inclusions; Piping (bars).
Non-ferrous materials	Hot rolling; Cold rolling; Extruding; Drawing.	PT; ET; UT; VT.	Cracks; Pitting; Indentations and grooves; Scratches; Laminations (flat products); Piping (bars); Seams; Stringers.	UT.	Cracks; Laminations; Piping; Inclusions (stringers).	UT; VT.	Rolled-in scale; Inclusions [a].	UT.	Inclusions; Piping (bars).

[a] Cutting faces.

Annex D
(informative)

Discontinuities in wrought forgings

Table D.1 — Discontinuities in wrought forgings

Material	Manufacturing process	Planar discontinuities				Volumetric discontinuities			
		Methods	Surface	Methods	Sub-surface	Methods	Surface	Methods	Sub-surface
Ferritic steels	Drop forging; Press forging; Hand forging; Hot and cold stamping.	ET; MT; PT; RT; UT; VT.	Cracks; Indentations and grooves; Scratches; Laps.	RT; UT.	Cracks; Laps; Inclusions.	RT; UT; VT.	Embedded scale [a]; Inclusions; Burns.	RT; UT.	Inclusions; Burst.
Non-ferrous materials	Drop forging; Press forging; Hand forging; Hot and cold stamping.	ET; PT; RT; UT; VT.	Cracks; Indentations and grooves; Scratches; Laps.	RT; UT.	Cracks; Laps; Inclusions.	RT; UT; VT.	Embedded scale; Inclusions [a]; Burns.	RT; UT.	Inclusions; Burst.

[a] Cutting faces.

Annex E
(informative)

Discontinuities in tubes and pipes

Table E.1 — Discontinuities in tubes and pipes

Material	Manufacturing process	Planar discontinuities				Volumetric discontinuities			
		Methods	Surface	Methods	Sub-surface	Methods	Surface	Methods	Sub-surface
Ferritic steels	All	ET [a]; MT; PT; RT; UT; VT.	Depends upon manufacturing process (see Annexes A, B, C).	MT; PT; RT; UT; VT.	Depends upon manufacturing process (see Annexes A, B, C).	ET [a]; MT; PT; RT; UT; VT.	Depends upon manufacturing process (see Annexes A, B, C).	ET [a]; MT; RT; UT.	Depends upon manufacturing process (see Annexes A, B, C).
Non-ferrous materials	All	ET [a]; PT; RT; UT; VT.	Depends upon manufacturing process (see Annexes A, B, C).	PT; RT; UT; VT.	Depends upon manufacturing process (see Annexes A, B, C).	ET [a]; PT; RT; UT; VT.	Depends upon manufacturing process (see Annexes A, B, C).	ET [a]; RT; UT.	Depends upon manufacturing process (see Annexes A, B, C).

[a] If applicable.

Annex F
(informative)

Discontinuities in in-service inspection

Table F.1 — Discontinuities in in-service inspection

Material and Manufacturing process	Discontinuities			
	Methods	Surface [c]	Methods	Sub-surface [b]
Ferrous steels, all processes	ET; MT; PT; RT; UT; VT.	Transgranular cracks; Intergranular cracks; Fatigue cracks. Cracking induced by: erosion; corrosion; impact; wear.	RT; UT.	Any discontinuity not breaking a surface.
Non-ferrous steels, all processes	ET; PT; RT; UT [a]; VT.	Transgranular cracks; Intergranular cracks; Fatigue cracks. Cracking induced by: erosion; corrosion; impact; wear.	RT; UT.	Any discontinuity not breaking a surface.

[a] If applicable.

[b] For example, to be found under paint and cladding and caused by corrosion.

[c] For example, due to pitting corrosion.

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