RADIOGRAPHIC TESTING

Qualification training according to the ISO 9712

RT

PROCESS	SYSTEM	METHOD	LEVEL / TECHNIQUE	SECTOR	CODE	VALID FROM	PREPARED BY
NDT	**ISO 9712**	RT	1, 2, 3	MS, w(e), c(e)	-	**1 / 2023**	**MAŘÁNEK**

INTRODUCTION

Purpose of Radiographic Testing method (RT, sometimes also referenced as X-ray) is detection of mainly internal defects in industrial parts and components using ionizing radiation.

RT qualified personnel has to have knowledge of its **physics principles**, be familiar with overall **requirements of most widely codes and standards**, be able to expand them to new applications and be **able to perform and document testing**.

Training focuses on **gaining knowledge and essential skills** to be further strengthened when collecting experience. Duration and content of the training **depends on the qualification level pursued** as well as the **product or industrial sector selected** (e.g. welding, casting, multisector applications etc.).

Training are designed to prepare participants for all examination parts – **general** (physics principles), **specific** (use of standards and codes), and **practical** (performance of the method) acc. to EN ISO 9712 in the ATG CERT Examination Center.

RECOMMENDED PUBLICATIONS

ATG publications

- RT – Radiographic Testing, Level 1, 2 (ATG handbook)
- RT – Collections of formulas (published by ATG)

Other publications

- Personnel Training Publications: Radiographic Testing (RT) Programmed Instruction Series (ASNT handbook)
- Level III Study Guide: Radiographic Testing Method (RT) (ASNT handbook)
- Relevant Discontinuities – Radiographic Testing (RT) (ASNT handbook)
- Nondestructive Testing Handbook, Third Edition: Volume 4, Radiographic Testing (ASNT handbook)

SYLLABUS COVERAGE

Training provides theoretical and practical training to understand Radiographic Testing (RT) principles, be familiar with various types of equipment, accessories, and other aids, and handling of tested parts and components to perform safely Radiographic Testing, report (and evaluate for Level 2 and Level 3) results of the testing.

TRAINING DURATION

SECTOR		LEVEL I	LEVEL II	LEVEL III
MS	Multisector	5 d (40 h)	10 d (80 h)	5 d (40 h)
w	Welds	5 d (40 h)	10 d (80 h)	5 d (40 h)
c	Castings	5 d (40 h)	10 d (80 h)	5 d (40 h)
we	Welds evaluation	N/A	9 d (72 h)	N/A
ce	Castings evaluation	N/A	9 d (72 h)	N/A

BODY OF KNOWLEDGE – DISCONTINUITIES OF MATERIALS

Content of this body of knowledge does not have dedicated part of examination, however it can be indirectly included in other examination parts.

	SUBJECT	LEVEL I	LEVEL II	LEVEL III
1	**Types of discontinuities**			
1.1	Differentiation of discontinuities based on their initiation	☐	☑	☑
1.2	Discontinuities of castings	☑	☑	☑
1.3	Discontinuities of forgings	☑	☑	☑
1.4	Discontinuities of welds	☑	☑	☑
1.5	Heat treatment	☑	☑	☑
1.6	Discontinuities initiated during processing and service	☑	☑	☑
1.6.1	Abrasion cracks	☐	☑	☑
1.6.2	Material fatigue	☐	☑	☑
1.6.3	Stress corrosion	☐	☑	☑
1.6.4	Creep	☐	☑	☑

BODY OF KNOWLEDGE – GENERAL PART

	SUBJECT	LEVEL I	LEVEL II	LEVEL III
1	**Physical Principles**			
1.1	Forms of radiation	☑	☑	☑
1.2	Atomic structure	☑	☑	☑
1.3	Radioactive isotopes	☑	☑	☑
1.4	Dependence of radiation intensity change in the distance of a radiation source	☑	☑	☑
2	**X-Ray And Gamma Radiation Production**			
2.1	X-ray	☑	☑	☑
2.1.1	X-ray production, function of X-ray tube	☑	☑	☑
2.1.2	X-ray tube head spectrum	☑	☑	☑
2.1.3	Construction of X-ray tubes	☐	☑	☑
2.1.4	Application of accelerators	☐	☑	☑
2.1.5	Mini and micro focal spot	☐	☑	☑
2.2	Gamma radiation	☑	☑	☑
2.2.1	Gamma radiation production	☑	☑	☑
2.2.2	Activity A	☑	☑	☑
2.2.3	Gamma ray cameras	☑	☑	☑
2.2.4	Comparison of X-ray and gamma radiation	☑	☑	☑
3	**Radiographic Contrast Theory**			

	SUBJECT	LEVEL I	LEVEL II	LEVEL III
3.1	Ionizing radiation, attenuation	☑	☑	☑
3.2	Primary and scattered radiation	☑	☑	☑
3.3	Interaction of ionizing radiation with matter	☑	☑	☑
3.4	Attenuation law and linear attenuation coefficient μ	☑	☑	☑
3.5	Half value layer	☑	☑	☑
3.6	Influence of radiation energy and product material on attenuation	☑	☑	☑
3.7	Build-up factor B	☐	☑	☑
3.8	Subject contrast	☐	☑	☑
3.9	Radiographic contrast	☑	☑	☑
4	**Film – Screen And Inherent (Film) Unsharpness**			
4.1	Radiographic film	☑	☑	☑
4.2	Characteristics and types of films	☑	☑	☑
4.3	Film sensitivity	☑	☑	☑
4.4	Gradation	☑	☑	☑
4.5	Selection of film systems type	☑	☑	☑
4.6	Screen	☑	☑	☑
4.6.1	Metal screen action	☑	☑	☑
4.6.2	Material and metal screen thickness	☑	☑	☑
4.6.3	Fluorescent screen	☐	☑	☑
4.7	Film unsharpness (inherent unsharpness)	☑	☑	☑
4.7.1	Definition and dimension of inherent unsharpness	☑	☑	☑
4.7.2	Inherent unsharpness and radiation energy	☑	☑	☑
4.7.3	Inherent unsharpness size and film type	☑	☑	☑
5	**Film Processing And Radiograph Inspection**			
5.1	Manual processing	☑	☑	☑
5.1.1	Dark room	☑	☑	☑
5.1.2	Development	☑	☑	☑
5.1.3	Developer	☑	☑	☑
5.1.4	Stop bath	☑	☑	☑
5.1.5	Fixing	☑	☑	☑
5.1.6	Washing and drying	☑	☑	☑
5.2	Automatic film development	☑	☑	☑
5.3	Radiograph (film) defects	☑	☑	☑
5.4	Radiograph inspection	☑	☑	☑
5.5	Viewers, illuminators	☑	☑	☑
5.6	Density and density measuring	☑	☑	☑
6	**Geometric Radiography Conditions And Exposure Latitude**			

	SUBJECT	LEVEL I	LEVEL II	LEVEL III
6.1	Geometric unsharpness	☑	☑	☑
6.2	Total unsharpness of a radiograph	☑	☑	☑
6.3	Minimal source to object (source side) distance	☑	☑	☑
6.4	Radiographic technique	☑	☑	☑
6.5	Exposure latitude	☐	☑	☑
7	**Radiographs – Detection Of Defects**			
7.1	Definition of the defect (imperfection)	☑	☑	☑
7.2	Image contrast (radiographic contrast)	☑	☑	☑
7.3	Scattered radiation	☑	☑	☑
7.4	Geometrical distortion	☑	☑	☑
7.5	Unsharpness	☑	☑	☑
7.6	Granularity	☑	☑	☑
7.7	Image of volumetric etalon	☐	☑	☑
7.8	Imaging of real defects	☐	☑	☑
7.8.1	Volumetric defects	☐	☑	☑
7.8.2	Planar defects	☐	☑	☑
8	**IQI – Image Quality Indicators**			
8.1	Purpose of IQIs	☑	☑	☑
8.2	Materials of IQIs	☑	☑	☑
8.3	Types of IQIs	☑	☑	☑
8.4	Hole-type IQIs and Wire IQIs	☑	☑	☑
8.5	Indicators of scattered radiation	☑	☑	☑
8.6	Image quality levels („sensitivity levels“)	☑	☑	☑
8.7	IQI location on inspected product	☑	☑	☑
9	**Radiographs Evaluation**			
9.1	Radiograph evaluation scheme	☑	☑	☑
9.2	Radiograph inspection	☑	☑	☑
9.3	Density and density measuring	☑	☑	☑
9.3.1	Luminous intensity	☐	☑	☑
9.3.2	Brightness and illumination	☐	☑	☑
9.3.3	Density – optical density	☑	☑	☑
9.4	Demands on viewer and interpreter	☐	☑	☑
9.5	Evaluation levels	☐	☑	☑
9.6	Evaluation	☐	☑	☑
10	**Special Applications**			
10.1	Non-conventional radiation sources	☑	☑	☑
10.1.1	Accelerators	☐	☑	☑
10.1.2	Neutron radiography	☐	☑	☑
10.2	Unique exposure techniques	☐	☑	☑

	SUBJECT	LEVEL I	LEVEL II	LEVEL III
10.3	Non-film detectors of ionizing radiation	☐	☑	☑
10.3.1	Fluoroscopy	☐	☐	☑
10.3.2	X-ray Image Intensifier	☐	☐	☑
10.3.3	Digital Detector Array (DDA) systems	☐	☐	☑
10.3.4	Phosphor imaging plates (IP) systems	☐	☐	☑

BODY OF KNOWLEDGE – SPECIFIC PART

The content of specific part is modified according to product sector which is covered by training. Multisector includes standards from all sectors. Level of detail paid to particular documents depends on the level of the training (Level I, Level II or III).

	STANDARD	LEVEL I	LEVEL II	LEVEL III
1	**General Methodology**			
EN ISO 5579	Non-destructive testing. Radiographic testing of metallic materials using film and X- or gamma rays. Basic rules	☑	☑	☑
EN ISO 19232-1	Non-destructive testing - Image quality of radiographs – Part1: Determination of the image quality value using wire-type image quality indicators	☑	☑	☑
EN ISO 19232-2	Non-destructive testing - Image quality of radiographs – Part2: Determination of the image quality value using step/hole-type image quality indicators	☑	☑	☑
EN ISO 19232-3	Non-destructive testing - Image quality of radiographs – Part 3: Image quality classes	☐	☑	☑
EN ISO 19232-4	Non-destructive testing – Image quality of radiographs – Part 4: Experimental evaluation of image quality values and image quality tables	☐	☐	☑
EN ISO 19232-5	Non-destructive testing - Image quality of radiographs- Part 5: Determination of the image unsharpness value using duplex wire-type image quality indicators	☐	☑	☑
EN 25580	Specification for minimum requirements for industrial radiographic illuminators for non-destructive testing	☑	☑	☑
EN ISO 11699-1	Non-destructive testing. Industrial radiographic film. Classification of film systems for industrial radiography	☑	☑	☑
EN ISO 11699-2	Non-destructive testing. Industrial radiographic films. Control of film processing by means of reference values	☑	☑	☑
EN 1330-3	Non-destructive testing. Terminology. Terms used in industrial radiographic testing	☑	☑	☑
ASTM E94	Standard Guide for Radiographic Examination	☐	☑	☑
ASTM E1742	Standard Practice for Radiographic Examination	☐	☐	☑
ASTM E747	Standard Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology	☐	☑	☑
ASTM E999	Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing	☐	☐	☑
ASTM E1025	Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology	☐	☑	☑

	STANDARD	LEVEL I	LEVEL II	LEVEL III
EN 12543	Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 5: Measurement of the effective focal spot size of mini and micro focus X-ray tubes	☐	☐	☑
EN 12679	Non-destructive testing. Determination of the size of industrial radiographic sources. Radiographic method	☐	☐	☑
2	**Castings**			
ASTM E1025	Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology	☐	☑	☑
EN 12543	Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 5: Measurement of the effective focal spot size of mini and micro focus X-ray tubes	☐	☐	☑
EN 12679	Non-destructive testing. Determination of the size of industrial radiographic sources. Radiographic method	☐	☐	☑
ASTM E1025	Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology	☐	☑	☑
EN 12543	Characteristics of focal spots in industrial X-ray systems for use in non-destructive testing - Part 5: Measurement of the effective focal spot size of mini and micro focus X-ray tubes	☐	☐	☑
EN 12679	Non-destructive testing. Determination of the size of industrial radiographic sources. Radiographic method	☐	☐	☑
ASTM E1025	Standard Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology	☐	☑	☑
3	**Welds**			
EN ISO 17636-1	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with film	☑	☑	☑
EN ISO 17636-2	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with digital detectors	☐	☐	☑
EN ISO 6520-1	Welding and allied processes. Classification of geometric imperfections in metallic materials. Fusion welding	☐	☑	☑
EN ISO 6520-2	Welding and allied processes. Classification of geometric imperfections in metallic materials. Welding with pressure	☐	☐	☑
EN ISO 5817	Welding. Fusion-welded joints in steel, nickel and titanium and their alloys (beam welding excluded) – Quality levels for imperfections	☑	☑	☑
EN ISO 10042	Welding. Arc-welded joints in aluminium and its alloys. Quality levels for imperfections	☐	☐	☑
EN ISO 13919-1	Welding. Electron and laser beam welded joints. Guidance on quality levels for imperfections. Steel	☐	☐	☑
EN ISO 17635	Non-destructive testing of welds. General rules for metallic materials	☐	☑	☑
EN ISO 10675-1	Non-destructive testing of welds. Acceptance levels for radiographic testing. Steel, nickel, titanium and their alloys	☐	☑	☑
EN ISO 10675-2	Non-destructive testing of welds. Acceptance levels for radiographic testing. Aluminum and its alloys	☐	☐	☑
ASTM E390	Standard Reference Radiographs for Steel Fusion Welds	☐	☑	☑
EN 13480-5	Metallic industrial piping. Inspection and testing	☐	☐	☑
EN 13445-5	Unfired pressure vessels – Part 5: Inspections and testing	☐	☐	☑

STANDARD		LEVEL I	LEVEL II	LEVEL III
EN 12952-6	Water-tube boilers and auxiliary installations. Inspection during construction; documentation and marking of pressure parts of the boiler	☐	☐	☑
EN 12953 - 5	Shell boilers. Inspection during construction, documentation and marking of pressure parts of the boiler	☐	☐	☑
EN ISO 10893-6	Non-destructive testing of steel tubes. Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections	☐	☐	☑
EN ISO 10893-7	Non-destructive testing of steel tubes. Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections	☐	☐	☑
ASME BPV Code Section V		☐	☐	☑
ASME BPV Code Section VIII		☐	☐	☑

BODY OF KNOWLEDGE – PRACTICAL PART

In the practical part of the training the trainees practice working with instructions and procedures as well as knowledge gained from the standards discussed in the specific part. Training and examination specimens are representative for given product sectors.

	SUBEJCT	LEVEL I	LEVEL II	LEVEL III
1	**General**			
1.1	Using of Viewers	☑	☑	☑
1.2	Density Measurement and calibration of Densitometers	☑	☑	☑
1.3	Assessment of Radiographs Quality	☑	☑	☑
1.4	Working with Exposure Charts	☑	☑	☑
2	**Making Radiographs According To Instructions And Processing**			
2.1	Welds	☑	☑	☑
2.1.1	Single Wall Technique: Plane parts; Centric; Eccentric; Curved objects – Source Inside	☑	☑	☑
2.1.2	Double Wall Technique: Single Wall Image; Double Wall Image – elliptic, perpendicular	☑	☑	☑
2.2	Castings	☑	☑	☑
2.2.1	Overview Technique	☑	☑	☑
2.2.2	Single Wall Technique	☑	☑	☑
2.2.3	Double Wall Technique	☑	☑	☑
3	**Evaluation of Weld and Castings Quality on the Base of Radiographs**			
3.1	Welds	☐	☑	☑
3.2	Castings	☐	☑	☑

BODY OF KNOWLEDGE – DOCUMENTATION

In the practical part of the training the trainees practice dealing with process documentation from reporting results to reports, drafting instructions and procedures.

	SUBEJCT	LEVEL I	LEVEL II	LEVEL III
1	**Test Report**			
1.1	Purpose	☑	☑	☑
1.2	Tested part	☑	☑	☑
1.3	Testing conditions	☑	☑	☑
1.4	Reporting findings	☑	☑	☑
1.5	Evaluation	☐	☑	☑
2	**Written Instruction**			
2.1	Validity range	☐	☑	☑
2.2	Personnel requirements	☐	☑	☑
2.3	Inspection range and area of interest	☐	☑	☑
2.4	Equipment and accessories	☐	☑	☑
2.5	Testing parameters and their verification	☐	☑	☑
2.6	Evaluation, acceptance criteria	☐	☑	☑
2.7	Reporting	☐	☑	☑
2.8	Post-testing activity	☐	☑	☑
3	**Written Procedure**			
3.1	Validity range	☐	☐	☑
3.2	Personnel requirements	☐	☐	☑
3.3	Inspection range and scheduled plan	☐	☐	☑
3.4	Equipment, accessories and control activities	☐	☐	☑
3.5	Setting of parameters	☐	☐	☑
3.6	Testing parameters	☐	☐	☑
3.7	Evaluation, acceptance criteria	☐	☐	☑
3.8	Documentation	☐	☐	☑
3.9	Post-testing activity	☐	☐	☑