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Non-destructive testing — NDT training syllabuses

Essais non destructifs — Programmes de formation en END

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

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

This first edition cancels and replaces ISO/TR 25107:2006.

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

Introduction

The body of technical knowledge required of non-destructive testing (NDT) personnel is essential for the development of deliverables concerning NDT methods. No deliverables can be developed appropriately for NDT methods, without sufficient information on the technical background knowledge of the personnel who utilize the methods.

Role of NDT

Non-destructive testing makes an important contribution to the safety, economic and ecological welfare of our society.

NDT is the only choice for the testing of an object which cannot be destroyed, modified or degraded by the testing process. This is generally required for objects which are to be used after testing, for example, safety parts, pipelines, power plants, and also constructions under in-service inspection, but even for unique parts in archaeology and culture.

NDT is based on physical effects at the surface or the inner structure of the object under test. Often, the outcome of the test needs to be interpreted to give a useful result; sometimes different NDT methods are combined or verified by other test methods.

NDT personnel and professional ethics

NDT personnel have a great responsibility, not only with respect to their employers or contractors but also under the rules of good workmanship. The NDT personnel is independent and free from economic influences with regard to his/her test results, otherwise the results are compromised. The NDT personnel is aware of the importance of his/her signature and the consequences of incorrect test results for safety, health and environment.

Finally, the NDT personnel is responsible for all interpretations of test results carrying his/her signature and he/she never signs test reports beyond his/her certification.

Annex B provides standards numbers that can be of interest for the application of the provisions laid out in this document.

Non-destructive testing — NDT training syllabuses

1 Scope

This document gives requirements and recommendations for non-destructive testing (NDT) training syllabuses, with the intention of harmonizing and maintaining the general standard of training of NDT personnel for industrial needs.

It also establishes the minimum requirements for effective structured training of NDT personnel to ensure eligibility for qualification examinations leading to third-party certification according to recognized standards. In addition to non-destructive testing in general, its guidelines for syllabuses cover acoustic emission testing, eddy current testing, leak testing, magnetic testing, penetrant testing, radiographic testing, ultrasonic testing, visual testing, thermographic testing, and strain gauge testing.

ISO/TS 25108 gives requirements and recommendations for NDT training organizations.

2 Normative references

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

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
adjustment
set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Types of adjustment of a measuring system include zero adjustment, offset adjustment, and span adjustment (sometimes called gain adjustment).

4 General

4.1 NDT training

Training syllabuses by themselves cannot guarantee competence of the trainees to provide adequate technical knowledge, since it is quite common that some students achieve excellent results whereas others fail in the same class. ISO 9712 provides the minimum training requirements for candidates who possess adequate skills and prior knowledge. If it is not the case, consideration for additional training should include:

a) level 1, 2 and 3 — mathematics;

b) level 1, 2 and 3 — materials and process;

c) level 3 — general knowledge common course applicable to all NDT methods.

As specified in ISO 9712, direct access to the level 2 examination requires the total training time for level 1, level 2 and direct access to level 3 requires the total training time shown for level 1, level 2 and level 3.

ISO 9712 also provides the opportunity for reductions in training duration for candidates seeking certification in more than one method or who have a certain educational degree in an NDT relevant subject. Thus, the training organizations should use discretion when implementing the syllabuses respective of their training environment taking into consideration product/industrial sectors and development or use of common focused courses which pertain to all NDT methods in developing their training curriculum.

4.2 Levels of competence

A three-level scheme, in accordance with ISO 9712, is used to define levels of competence to indicate the required depth of understanding, knowledge and application of material.

Level 1

— Acquire a general knowledge of topic areas.

— Identify equipment and accessories.

— Identify common reference documents.

— Recognize when material is applicable or why it is relevant.

— Demonstrate understanding by performing instructed inspection tasks.

Level 2

— Attain a sound understanding of concepts and principles.

— Develop a sound conceptual and comprehensive technical knowledge.

— Develop a sound working knowledge of procedures.

— Become familiar with common reference documents.

— Become proficient in the application of knowledge to practice.

— Apply concepts and techniques to inspection situations.

— Analyse information to make preliminary conclusions.

Level 3

— Attain an in-depth understanding of concepts and principles.

— Develop in-depth comprehensive technical knowledge of procedures.

— Be proficient in the application of knowledge to practice.

— Be proficient with the use of reference documents.

— Analyse information to form conclusions.

— Apply concepts and techniques to new inspection situations.

NOTE Where topics/subjects/content are listed across multiples levels in Tables 1 through 21, this indicates a more in-depth knowledge is required at the higher level(s).

4.3 General environmental and safety considerations

4.3.1 Non-destructive testing is often applied in conditions where the safety of the operator can be in danger owing to local conditions, or where the application of the particular NDT method or technique itself can compromise the safety of the operator and others in the vicinity.

An essential element of any training for NDT personnel shall therefore be safety. The duration of the training for this subject should be adequate and be provided in addition to the technical training associated with a particular NDT method.

4.3.2 Additional training in radiation safety shall be required prior to radiographic training.

4.3.3 General safety considerations include, but are not necessarily limited to, the following:

— environmental conditions (heat, cold, humidity);

— toxicity (NDT materials, tested products, atmosphere);

— radiation safety (NDT materials, products);

— electrical safety (NDT equipment, lethal voltages, EMC);

— potential for injury to personnel (working at height or in other dangerous environments);

— personal protection equipment (clothing, radiation dosimeters);

— pressure test safety.

5 Radiographic testing (RT) — Levels 1, 2 and 3

The radiographic testing training shall be in accordance with Tables 1 and 2.

Table 1 — General content

		Level 1 (% of total duration)	Level 2 (% of total duration)	Level 3 (% of total duration)
5.1	Introduction to terminology and history of radiographic testing (RT)	3	1	1
5.2	Physical principles of the method and associated knowledge	15	10	15
5.3	Product knowledge and capabilities of the method and its derived techniques	15	15	20
5.4	Equipment	25	20	25
5.5	Information prior to testing	5	8	5
5.6	Testing	30	25	2,5
5.7	Evaluation and reporting	5	10	7,5
5.8	Assessment	0	5	10
5.9	Quality aspects	2	5	8
5.10	Developments	0	1	6

NOTE Annex A provides guidance on the training process for advanced radiographic techniques.

Table 2 — Radiographic testing (RT) — Levels 1, 2 and 3

Content			RT-F (Film)			RT — D (Digital)			RT-S (Radioscopy)		
			Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
5.1 Introduction to terminology and history of radiographic testing (RT)	History		X	X	X	X	X	X	X	X	X
	Purpose of NDT	What is testing?	X	X	X	X	X	X	X	X	X
		What is the purpose of NDT?	X	X	X	X	X	X	X	X	X
		At what stage of life is NDT performed on a “product”?	X	X	X	X	X	X	X	X	X
		How does it add value?	X	X	X	X	X	X	X	X	X
		Who may carry out NDT?	X	X	X	X	X	X	X	X	X
		Main NDT methods	X	X	X	X	X	X	X	X	X
	Purpose of radiographic testing (RT)	Definition	X	X	X	X	X	X	X	X	X
		Applicability and limitations	X	X	X	X	X	X	X	X	X
	Terminology	Electromagnetic radiation	X	X	X	X	X	X	X	X	X
		Energy	X	X	X	X	X	X	X	X	X
		Dose	X	X	X	X	X	X	X	X	X
		Dose rate	X	X	X	X	X	X	X	X	X
		Wavelength	X	X	X		X	X		X	X
		Intensity	X	X	X	X	X	X	X	X	X
		Dose rate constant	X	X	X		X	X		X	X
		Activity	X	X	X	X	X	X			X
	Relevant standards	See Annex B		X	X		X	X		X	X
5.2 Physical principles of the method and associated knowledge Concepts necessary for understanding the physical principles of radiographic testing (physics, mathematics) may be the object of a preliminary course	General	Structure of the atom	X	X	X	X	X	X	X	X	X
		Electromagnetic spectrum	X	X	X	X	X	X	X	X	X
		Sources of radiation and its properties:									
		— X-rays	X	X	X	X	X	X	X	X	X
		— Gamma rays	X	X	X	X	X	X	X	X	X
		— Neutrons			X			X			X
		X-ray and gamma ray spectrum	X	X	X	X	X	X	X	X	X
		Essential radiographic parameters:									
		— Voltage	X	X	X	X	X	X	X	X	X
		— Current	X	X	X	X	X	X	X	X	X

Table 2 *(continued)*

Content			RT-F (Film)			RT — D (Digital)			RT-S (Radioscopy)		
			Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
		— Activity	X	X	X	X	X	X	X	X	X
		Radiation filters		X	X		X	X		X	X
		Focal spot	X	X	X	X	X	X	X	X	X
		Dose	X	X	X	X	X	X	X	X	X
		Dose rate	X	X	X	X	X	X	X	X	X
		Dose rate constant	X	X	X		X	X		X	X
	Attenuation of radiation	General mechanism of interaction:									
		— Photoelectric effect	X	X	X	X	X	X	X	X	X
		— Compton effect	X	X	X	X	X	X	X	X	X
		— Pair production	X	X	X		X	X		X	X
		HVL, TVL and attenuation law	X	X	X	X	X	X	X	X	X
		Hardening of radiation,	X	X	X	X	X	X	X	X	X
		Scattered radiation and build up factor	X	X	X	X	X	X	X	X	X
		Filtering and collimation	X	X	X	X	X	X	X	X	X
		X-ray fluorescence	X	X	X	X		X		X	X
		Attenuation of neutrons and electrons			X			X			X
	Radiation contrast, noise	Contrast, noise, granularity	X	X	X	X	X	X	X	X	X
		Specific contrast		X	X		X	X		X	X
		Scatter influence	X	X	X	X	X	X	X	X	X
		Signal-to-noise ratio (SNR)				X	X	X	X	X	X
		Contrast-to-noise ratio					X	X		X	X
		Unsharpness	X	X	X	X	X	X	X	X	X
		Basic spatial resolution				X	X	X	X	X	X
		Pixel size				X	X	X	X	X	X
		Normalized SNR (SNR_N)				X	X	X		X	X
	Optimization of image quality	Compensation principles:									
		— Contrast vs SNR					X	X		X	X
		— Basic spatial resolution vs SNR					X	X		X	X
		— Local unsharpness vs SNR					X	X		X	X

Table 2 *(continued)*

Content			RT-F (Film)			RT — D (Digital)			RT-S (Radioscopy)		
			Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
		Scatter protection	X	X	X	X	X	X	X	X	X
		Maximum/optimum X-ray voltage		X	X		X	X		X	X
	Geometrical projection conditions	Geometrical and inherent unsharpness	X	X	X	X	X	X	X	X	X
		Geometrical magnification		X	X		X	X	X	X	X
		Effect of magnification		X	X	X	X	X	X	X	X
		Optimum magnification			X		X	X		X	X
		Difference between radiography and radioscopy		X	X		X	X		X	X
		Law of the squared distance	X	X	X	X	X	X	X	X	X
	Image quality indicators	Wire type	X	X	X	X	X	X	X	X	X
		Step hole type	X	X	X	X	X	X	X	X	X
		Plate hole type	X	X	X	X	X	X	X	X	X
		Duplex wire type	X	X	X	X	X	X	X	X	X
		Measurement of basic spatial resolution		X	X		X	X		X	X
		Converging line pairs			X		X	X		X	X
		Line pair gauges (MTF)			X			X			X
5.3 Product knowledge and capabilities of the method and its derived techniques	General defects	Processes overview:									
		— Casting		X	X		X	X		X	X
		— Forging		X	X		X	X			X
		— Welding		X	X		X	X		X	X
		— Tubes and pipes		X	X		X	X			X
		— Wrought products		X	X		X	X			X
		— Composite material		X	X		X	X		X	X
		Types of discontinuities	X	X	X	X	X	X	X	X	X
		Fracture mechanics			X			X			X
		Working load			X			X			X
		Material properties		X	X		X	X		X	X
		Origin of defects		X	X		X	X		X	X
		Evaluation		X	X		X	X		X	X

Table 2 *(continued)*

Content			RT-F (Film)			RT — D (Digital)			RT-S (Radioscopy)		
			Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
	Influence on detectability	Type of defect	X	X	X	X	X	X	X	X	X
		Size	X	X	X	X	X	X	X	X	X
		Orientation	X	X	X	X	X	X	X	X	X
		Number of exposures		X	X		X	X		X	X
		Beam direction	X	X	X	X	X	X	X	X	X
		Geometric distortion								X	X
		Increase in wall thickness		X	X		X	X		X	X
		Thickness ranges for X- and gamma rays		X	X		X	X		X	X
		Number of exposures vs distortion angle (tubes and pipes)		X	X		X	X		X	X
5.4 Equipment	Radiation sources — X-ray sources	Standard sources:									
		— Types of sources	X	X	X	X	X	X	X	X	X
		— Stationary vs mobile	X	X	X	X	X	X			
		— Construction and function of X-ray tubes	X	X	X	X	X	X	X	X	X
		— Unipolar vs bipolar		X	X		X	X		X	X
		Special sources		X	X		X	X		X	X
		Generation of high voltage		X	X		X	X		X	X
		Cooling	X	X	X	X	X	X	X	X	X
		Handling	X	X	X	X	X	X	X	X	X
		Parameters:									
		— kV	X	X	X	X	X	X	X	X	X
		— mA	X	X	X	X	X	X	X	X	X
		— Spot size	X	X	X	X	X	X	X	X	X
		Measurement of parameters		X	X		X	X		X	X
	Radiation sources — Gamma sources	Container:									
		— Shielding	X	X	X	X	X	X			
		— Classes of containers			X			X			
		Transportation	X	X	X	X	X	X			
		Source holder and capsula:									

Table 2 *(continued)*

Content			RT-F (Film)			RT — D (Digital)			RT-S (Radioscopy)		
			Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
		— Handling and projection	X	X	X	X	X	X			
		— Special design		X	X		X	X			
		— Collimation	X	X	X	X	X	X			
		Parameters:									
		— Isotope type	X	X	X	X	X	X			
		— Spectrum	X	X	X	X	X	X			
		— Energy	X	X	X	X	X	X			
		— Activity	X	X	X	X	X	X			
		— Source size	X	X	X	X	X	X			
		— Half life	X	X	X	X	X	X			
	Film	Construction:	X	X	X			X			
		— Latent image information origin	X	X	X			X			
		— Base, emulsion, silver bromide, grain size, grain form	X	X	X			X			
		— Photo process	X	X	X			X			
		Processing:									
		— Properties of film systems	X	X	X			X			
		— Characteristic curve	X	X	X			X			
		— Film gradient, film contrast, speed	X	X	X			X			
		— Influence of film processing	X	X	X						
		— Sensitivity	X	X	X						
		— Granularity	X	X	X						
		— Detail perceptibility		X	X						
		Classification of film systems	X	X	X						
		Quality assurance with film test strips		X	X						
		Film screens:									
		— Type of screens	X	X	X						
		— Inherent unsharpness	X	X	X						