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Jurisdiction	*Civil to be evaluated under Reg. (CE) 428/2009 as amended*
Export Classification/Category	*No Export Controlled Technology (NECT)*

Requirements for the use of tomographic inspection for aerospace components acceptance

19th X-ray & CT Forum Hamburg - 10 September 2024

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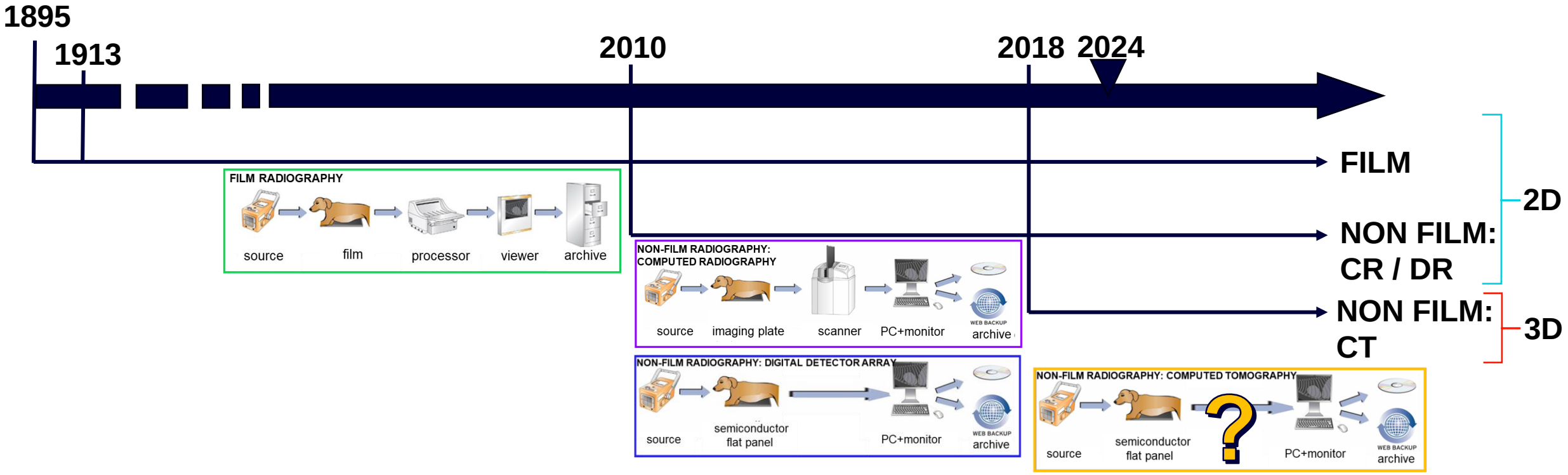
Scope

- Outline all the steps that the tomographic control process must follow for its use for parts resolution in the aeronautical sector

  - The approach used is that of:
    - provide contextualization and some basic information on tomographic control
    - build an outline of a hypothetical process procedure to be followed in the application of the inspection process

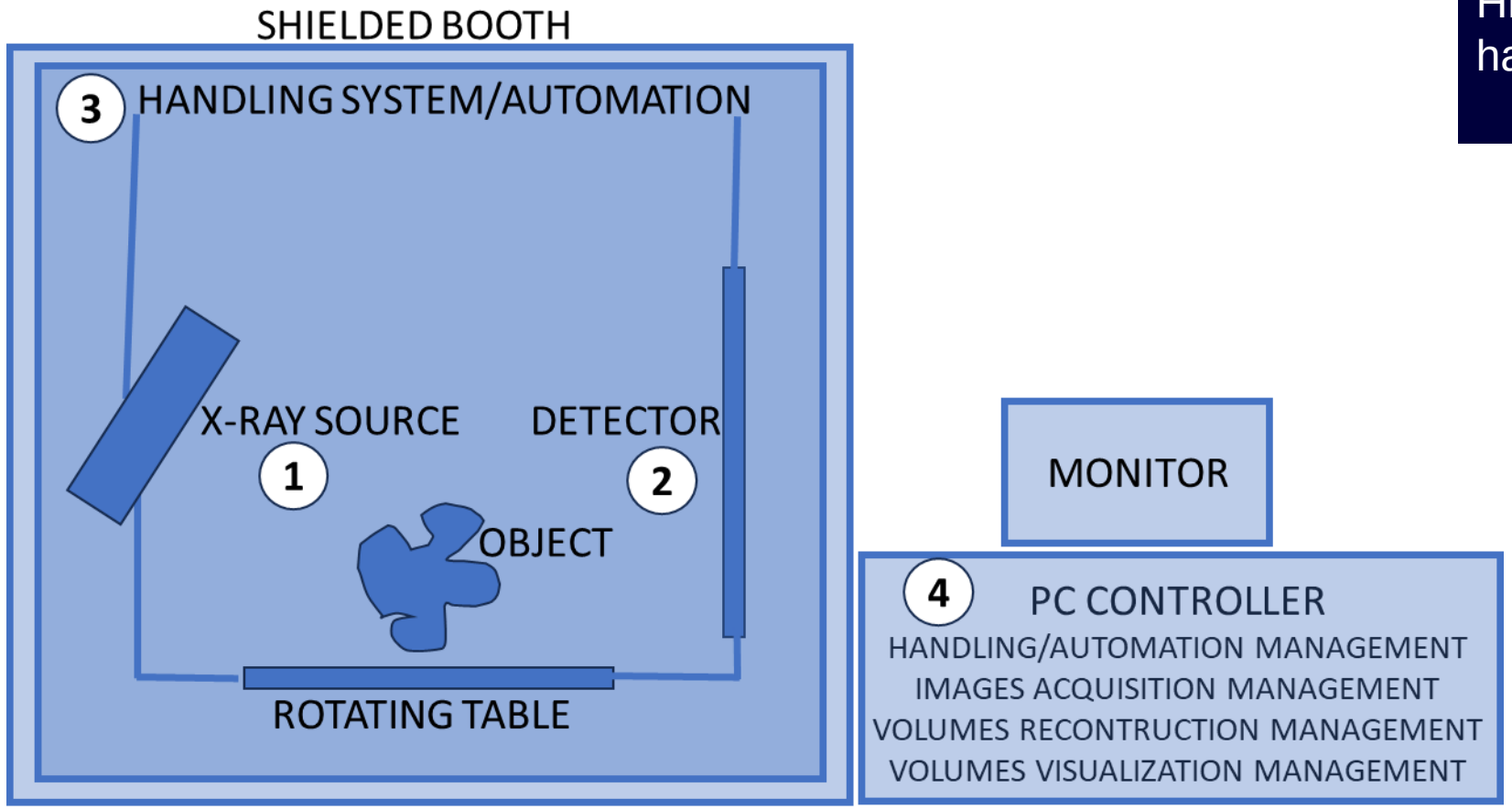
  - The starting points for this activity are:
    - international standards relating to tomography
    - the experience of the Avio Aero group in the introduction of tomographic control for deliberative purposes

Context



Tomography is to be considered a non-film sub-technique of radiographic control

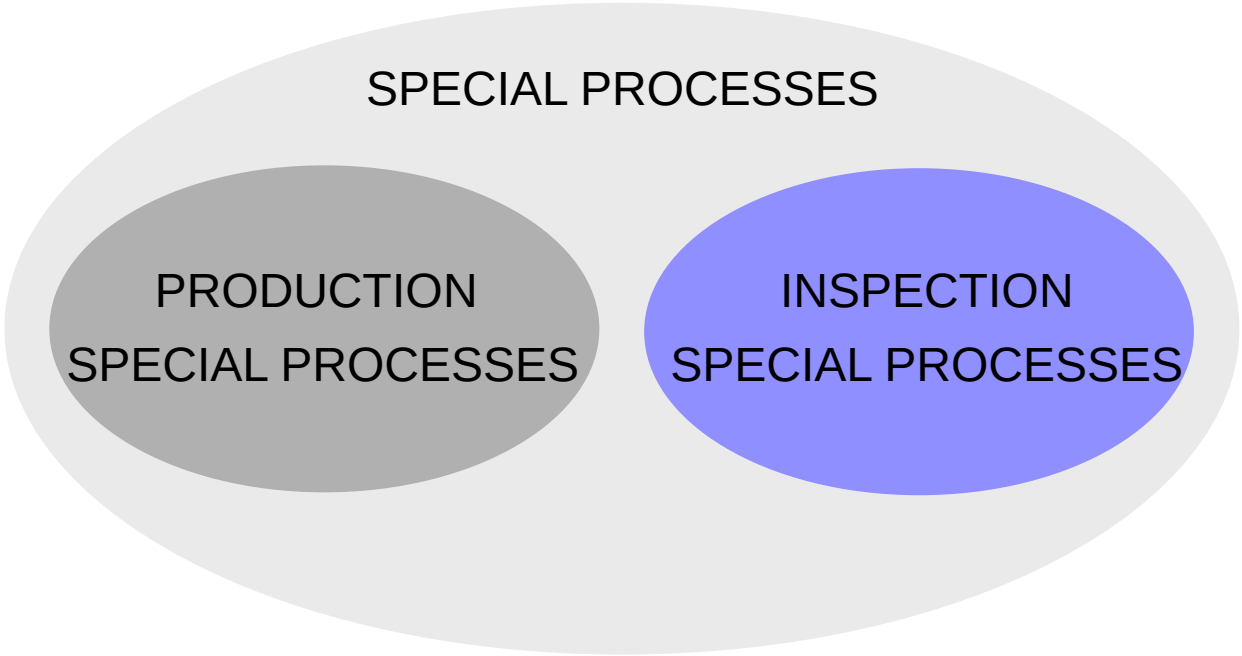
Tomographic equipment (CT scan)



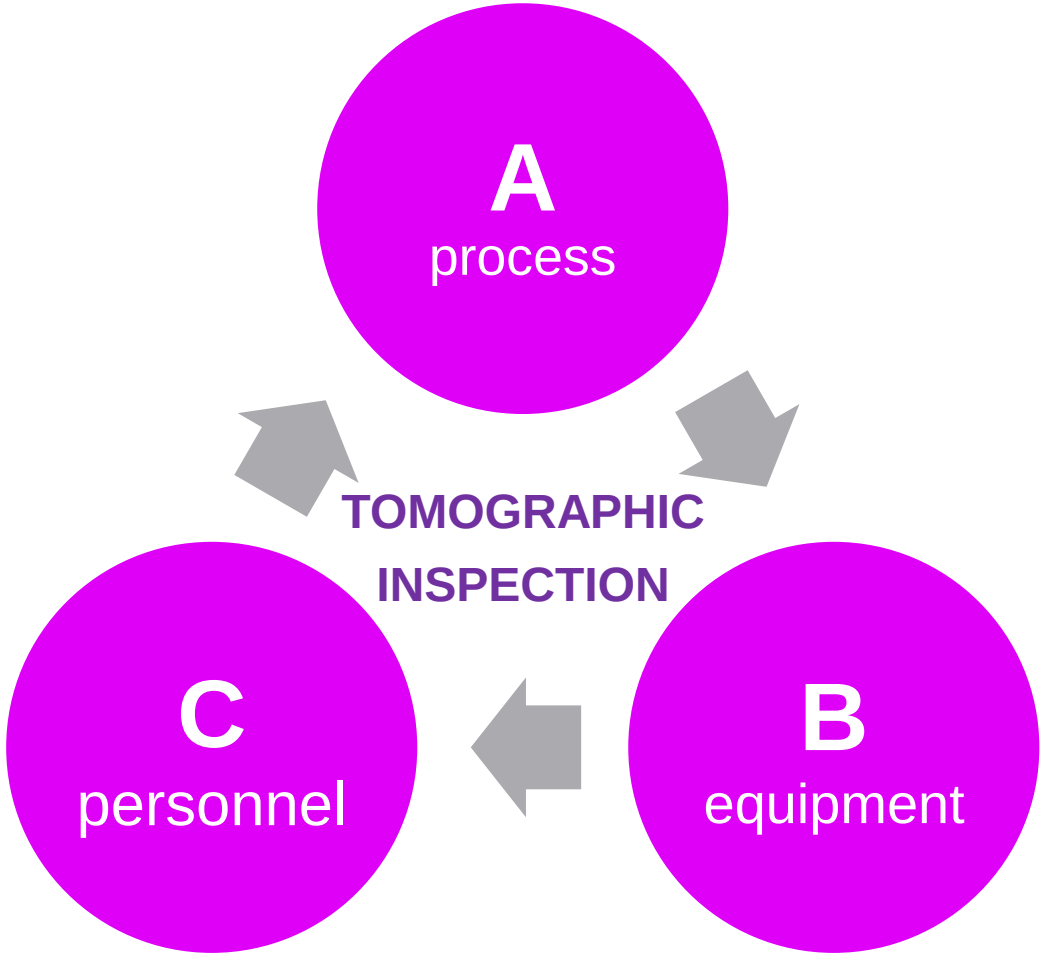
High variety of features, both at hardware and software level

There is no unique solution for creating a tomographic system but it depends on the manufacturer

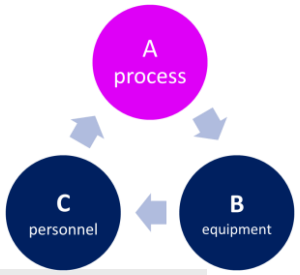
Special process management in aerospace



- SAFETY
- RELIABILITY
- REPRODUCIBILITY



Section A: the tomographic inspection process – definition and control



To guarantee the inspection process and its repeatability it is essential to define:

Scope:

- ❑ investigation of a component or a portion of it to verify its correct assembly or functioning
- ❑ inspection of a component for manufacturing defects
- ❑ dimensional analysis of a component
- ❑ …

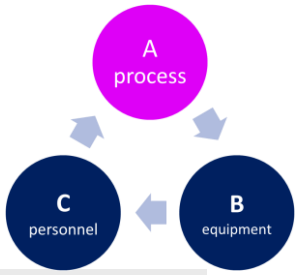
Applicability: e.g.. type of parts

- ❑ assembled parts
- ❑ additive manufacturing parts
- ❑ turbine blades
- ❑ composites
- ❑ …

Limits:

- ❑ material
- ❑ thickness
- ❑ geometry
- ❑ part dimension
- ❑ …

Section A: the tomographic inspection process – definition and control



To guarantee the inspection process and its repeatability it is essential to define:

Main process phases:

- ❑ acquisition
- ❑ reconstruction
- ❑ visualization
- ❑ evaluation/analysis
- ❑ archival

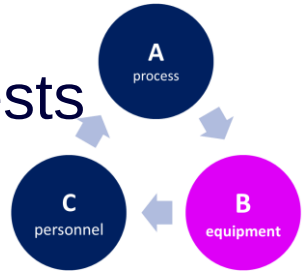
Image quality:

- ❑ general principles
- ❑ artefacts management
- ❑ Use of RQI (ASTM E1817)
- ❑ …

Process data card:

- ❑ significant process parameters
- ❑ acquisition technique
- ❑ reconstruction technique
- ❑ volume management
- ❑ visualization during inspection
- ❑ data estraction
- ❑ report standardization post evaluation

Section B: equipment–tomographic system, qualification and maintenance tests



The requirements of the system are to maintain its efficiency within the limits identified at its installation

Main equipment components:

- ❑ list
- ❑ caracteristics
- ❑ minimum requirement
- ❑ periodical checks/calibration
- ❑ …

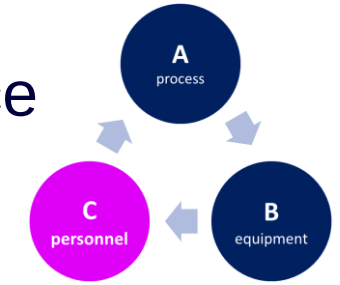
Fuctional tests and stability:

- ❑ CDF (ASTM E1695)
- ❑ MTF (ASTM E1695)
- ❑ axis alignment
- ❑ Dimensional verification for indications measurement
- ❑ metrological calibration (VDI/VDE 2630 or prEN ISO 10360-11)
- ❑ test tool description
- ❑ baseline values identification and checks frequency

Risk management plan defintion:

- ❑ detector change or maintenance
- ❑ x-ray source change or maintenance
- ❑ …

Section C: process personnel – qualification management and maintenance



Requirement: personnel shall be qualified according to NAS410 / EN 4179

Table 1 — Minimum formal training hours for Level 1 and Level 2

	Level 1	Level 2 with previous Level 1 certification	Level 2 without previous Level 1 certification
PT	16	16	32
MT	16	16	32
TT	20	40	60
ET	40	40	80
UT	40	40	80
RT film or non-film	40	40	80
RT film and non-film	60	60	120

Table 2 — RT formal training hours for transition to film and non-film

Additional formal training hours		
Current Level 1	Current Level 2	Current Level 1 to Level 2 film and non-film
20	40	80

Table 3 — Minimum experience requirements for Level 1 and Level 2

	Experience time in hours		
	Level 1 (Trainee experience)	Level 2 with previous Level 1 certification	Level 2 without previous Level 1 certification
PT	130	270	400
MT	130	400	530
TT	200	400	600
ET	200	600	800
UT	200	600	800
RT film or non-film	200	600	800
RT film and non-film	220	780	1 000

Table 4 — RT experience requirements for transition to film and non-film

Additional Minimum Experience Time in Hours		
Current Level 1	Current Level 2	Current Level 1 to Level 2 film and non-film
20	200	800

BS EN 4179:2021
EN 4179:2021 (E)

No specific definition of what «RT non-film» is

Can already qualified «RT non film» personnel automatically operate and accept parts with CT? (Are all RT non-film sub-techniques «the same»?)

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UK NANDTB model

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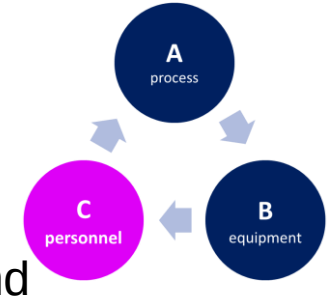


Reference: NANDTB/30: UK NANDTB Interim Policy for 3D Non-Film radiographic testing training and qualification – initial issue 5 Sep 2022; expiration 5 Sep 2024, unless extended or withdrawn

Scope: facilitate the introduction of 3DNF RT conversion training for an initial cadre of EN4179 Level 2 and Level 3 personnel currently qualified in 2D Non-Film RT sub-techniques (eg Computed Radiography, Digital Radiography, etc)

- conversion guideline
- standardized process

Eligibility: Non-film L2

Training: general: 24 h – CT theory

specific: 16 h – equipment in use

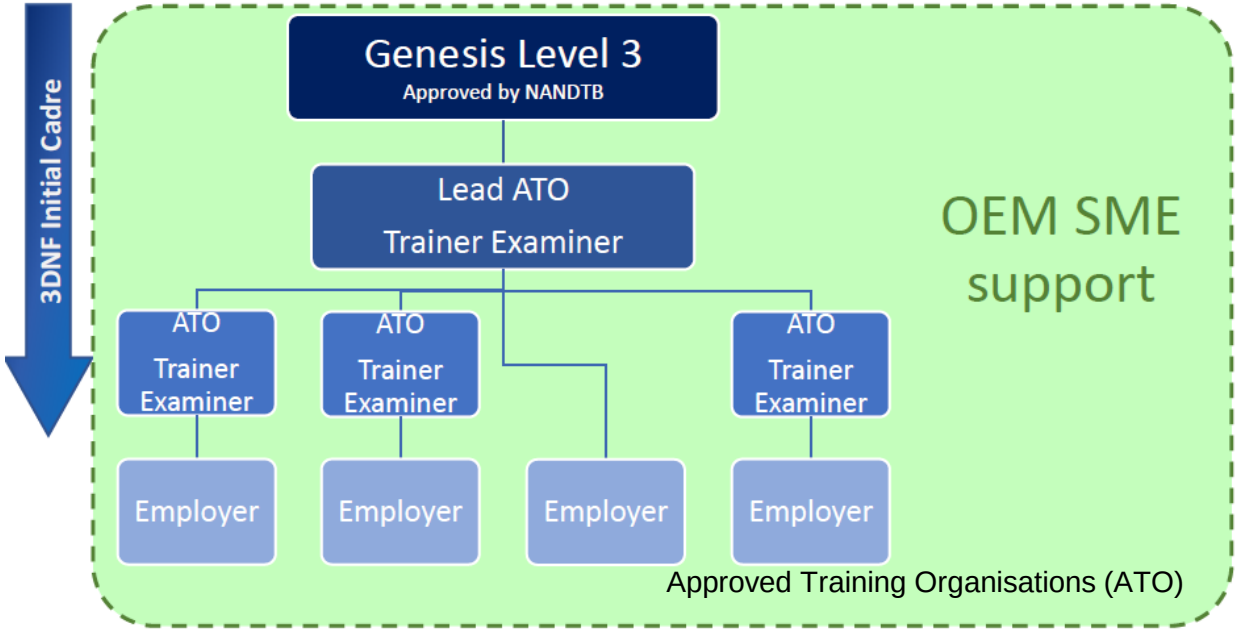
Experience: 80 h with tutor

Exams: general – 30 closed book questions (min. 70%)

specific – 30 open book questions (min. 70%)

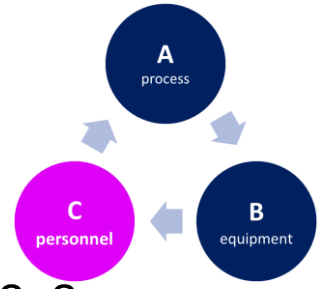
practical – 2 test samples for acquisition and evaluation (min. 70%)

minimum average score: 80%



ITANDTB model

ITALIAN AEROSPACE NON DESTRUCTIVE TESTING BOARD
COMITATO AEROSPAZIALE NAZIONALE PER I CONTROLLI NON DISTRUTTIVI



Reference: ITANDTB-12 Guideline for Computed Tomography (CT) RT non film technique Levels 1, 2, 3 personnel training and qualification – initial issue 26 July 2024

Scopo: guideline definition for CT personnel qualification management

- qualification process starting from no previous qualification in RT method
- qualification process with transition at same qualification levels
- identification of a group of experts RT non film levels 3 from CV and experience

Eligibility: (applicable only to the group of experts) RT non film qualification for at least 5 years

Training: same as per RT non film according to EN4179/NAS410 in case of no previous RT qualification
from 20 to 40 hours depending on the level for transition

Experience: same as per RT non film according to EN4179/NAS410 in case of no previous RT qualification
from 100 to 400 hours depending on the level for transition

Exam: same as per RT non film according to EN4179/NAS410 in case of no previous RT qualification
integrative exam as RT technique for transition
examination performed in a ITANDTB recognized Training and Examination Center

ITANDTB model

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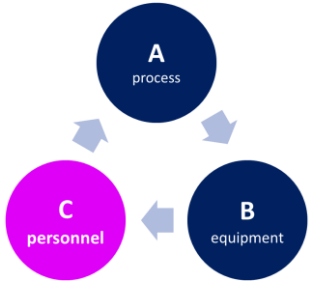

Expert L3 (L3 RT 3DNF CT)

The application is evaluated on the basis of the following evidence:

- Previous qualification at level 3 RT non-film for at least 5 years
- Documented Formal Training 3DNF CT:
  - 40 hours of course dedicated to tomography (evidence: certificate of participation, verification of learning and syllabus
  - Course on software for the management, manipulation and evaluation of tomographic volumes and/or course on tomographic equipment provided by the system manufacturer (evidence: certificate of participation)
- Documented experience with details of the activities carried out (minimum 200 hours). The activities below reported are representative of the topics in relation to which it is necessary to provide evidence of the activities carried out:
  - Preparation/approval of tomographic work instructions for the evaluation of parts e for the periodic maintenance of tomographic systems
  - Evaluation of tomographic volumes and familiarity with applicable acceptability standards
  - Choice and evaluation of tomographic systems

ITANDTB model

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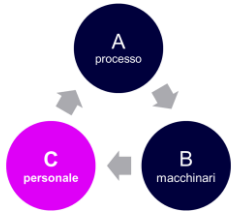

Dedicated CT Syllabus for each qualification level

- Basic Theory: special processes and NDT, personnel qualification
- Test Principles: x-ay generation, x-ray source, detectors, digital image
- Safety
- Process phases and paramenters
- Process control
- Applicable techniques
- Applicable documents
- Evaluation and interpretation
- Product forms and materials - defect formation and characterization

Dedicated experience guideline with % of suggested time to spend for each topic for each qualification level

- Software
- Equipment
- Calibration
- Volumes management and evaluation
- CT procedures application and issuing

Remarks and Conclusions

Tomography is to be considered a non-film sub-technique of radiographic control

The complexity of the method forces us to establish the rules of the game in advance: the process requirements

Each step of the process must be standardized and described in detail to ensure repeatability

- through both general and dedicated procedures for the individual component
- through the definition of a test plan that monitors the reliability of the system
- through a robust qualification process of the control personnel

Each of the phases requires a high activation energy in terms of time and resources

Only after having created the process + equipment + personnel structure it is possible to perform the first acquisition and inspection which can be followed by the acceptance of an airworthy component


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