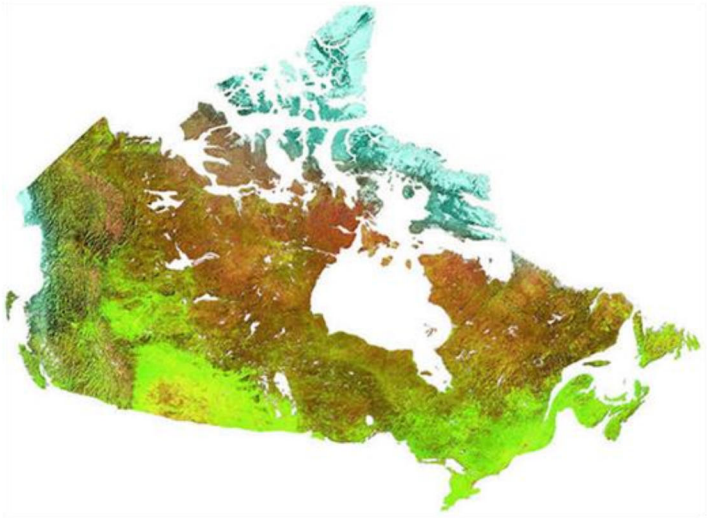
Radiographic Testing

Examination Guide for Initial Certification



Aerospace Sector

Canada

Contact Information

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Ce guide est aussi disponible en français à l'adresse suivante :

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Overview of NRCan National Non-destructive Testing Certification Body Services

The Natural Resources Canada (NRCan) National Non-Destructive Testing Certification Body (NDTCB) manages Canada's nation-wide program for the certification of individuals performing non-destructive testing (NDT). The NRCan NDTCB certifies individuals according to CAN/CGSB-48.9712 / (ISO 9712, IDT) standard.

In performing this function, the NRCan NDTCB carries out the following tasks:

a) Examines the information provided by the applicant to ensure that the applicant has the basic education, recommended NDT training and experience required by the standard.
b) Prepares, administers and evaluates both written and practical examinations.
c) Maintains a network of examination centres across Canada for both written and practical examinations.
d) Renews and recertifies certificates as specified by the standard.

In certifying a candidate, the NRCan NDTCB only attests that the candidate has demonstrated sufficient knowledge, skill, training and experience to meet the requirements of the CAN/CGSB 48.9712 standard. The NRCan NDTCB cannot attest to the certificate holder's competence in any specific situation at the time of original certification, or at any time thereafter.

In undertaking the administration of the program, the NRCan NDTCB attempts to provide the unbiased Canada-wide services required to implement a national program. A group of Scheme, Technical and Advisory Committees composed of stakeholders and individuals knowledgeable about NDT in Canada advises the NRCan NDTCB on the operation of this program.

IMPORTANT NOTICE

The candidate is responsible to ensure that the examination centre has proof of their Examination Admittance and Registration form issued by the NRCan NDTCB prior to the scheduled practical examination/re-examination. For written examination, an Electronic Written Authorization issued by NRCan NDTCB is required prior to purchasing an electronic written examination/re-examination. Failure to do this may delay the start time of the certification examination and may increase cost to the candidate.

In accordance with CAN/CGSB-48.9712-2022 / (ISO 9712:2021, IDT section 8.5.2 a candidate who fails to achieve a grade of at least 70% on each individual written examination element (i.e. general, specific), written instruction or each practical examination specimen/subpart may retake the examination according to the following criteria and schedule:

> A candidate who fails to obtain the pass grade for any examination element or practical examination specimen/subpart may be re-examined twice in the failed examination, provided that the re-examination takes place not sooner than 1 month and shall not exceed 2 years after the original examination.

The NDT Certification Body reserves the right of choice for written or practical examination components.

All practical examination times are shown in increments of ½ day or 1 day; ½ day shall be considered a maximum of 4 hours and 1 day shall be considered a maximum of 8 hours. Requests for accommodation (such as additional examination time) can only be granted with authorization from the NRCan NDTCB, following its "8.5-009 - NRCan NDTCB Procedure for Consideration of Candidate Requests for Accommodation". The authorized accommodations shall be noted in the candidate's examination registration approval and/or examination admittance and registration form. It is the candidate's responsibility to notify the examination centre of these accommodations at least 10 working days in advance of the examination.

NOTE: Additional information/instruction may be provided to the candidate at the start of the examination. The NRCan NDTCB may have implementation rules and policies that supersede the information provided within this guide.

Suggestions for Success: Written Examinations

1 The NRCan NDTCB recommends that all candidates for NDT written qualification examinations study extensively on their own time using the suggested reference material, in addition to the material learned during the method/level-specific training course, prior to attempting a written examination. Simply using your knowledge obtained by completing the theoretical portion of the training course will not adequately prepare you to succeed in your written examinations.

Note: You should not use the results of your end-of-course examination from your method/level-specific training course to estimate your level of success on the NRCan NDTCB written qualification examinations.

2 To assess your knowledge/abilities in preparation for a written examination, the NRCan NDTCB recommends completing/reviewing the following sample question resources available for personal purchase:
   a) Eclipse Scientific Test Maker Questions Data Base
   b) Supplements to Recommended Practice SNT-TC-1A (Question and Answer Books)

3 When you begin your written examination, ensure that you carefully read the examination instructions prior to reading and answering the questions.

4 Before you answer a multiple-choice question, ensure that you carefully read the stem (beginning portion) of the question and each alternative answer in order to accurately understand the question.

5 Remember, that although more than one multiple-choice alternative answer may appear to be correct or partially correct, only the **best** answer is correct.

6 If you have difficulty with choosing an answer to a multiple-choice question, proceed by first eliminating the alternative answers that you believe are incorrect, and then choose between the remaining alternative answers.

7 If you find that you cannot answer a question, proceed to the next question(s), and return to any unanswered questions prior to the end of the examination. Do not spend too much time on difficult questions at the expense of completing the remaining questions.

Reference Material

The material identified in this guide as reference study material may be purchased from the following sources:

Canadian Institute for NDE (CINDE) 135 Fennell Avenue W. Hamilton, Ontario L8N 3T2 Canada Telephone: (905) 387-1655 or 1 800-964-9488 Facsimile: (905) 574-6080	ASNT 1711 Arlingate Lane P.O. Box 28518 Columbus, Ohio 43228 - 0518 U.S.A. Telephone: (614) 274-6003 or 1-800-222-2768 Facsimile: (614) 274-6899

Radiographic Testing Level 2

Radiographic Testing Level 2 (RT2) - Aerospace Sector Examination Scheme in Accordance with CAN/CGSB-48.9712

Examination Part	Pass Grade	Examination Content	Duration
General Written Examination (Same as RT2 EMC General Exam)	≥70%	• 40 multiple choice questions on the theoretical principles of RT.	1 hour & 20 minutes
AS Written Examination	≥70%	• 35 multiple choice questions (total) ➢ 5 questions on codes (worth 2pts each). ➢ 30 questions on RT applications and techniques.	1 ¾ hours
Radiation Protection Paper	≥70%	• 25 multiple choice questions applicable to radiation safety	1 hour
Practical Examination (Aerospace Sector)	≥70% (on each specimen/ subpart)	• General Equipment Check (General Practical, only required if not successfully completed for RT level 1 certification) ➢ Produce an exposure chart on semi-log graph paper for a given exposure energy. ➢ Make the required settings and operate the equipment properly in order to obtain satisfactory results.	2 hours
		• Four (4) specimen inspections, including inspection technique reporting sheets for each. All structures/components are to be inspected using x-ray. • Interpret 25 radiographs • Detailed written instruction for one (1) of the inspected specimens	14 hours

Reference Material for RT2 A/S Written Examination Preparation

General and A/S Examinations

1. Aircraft Maintenance and Repair, by Delp/Bent/McKinley
2. Advisory Group for Aerospace Research & Development by AGARD-AG-201-Vol.1
3. Volume 17 Non-destructive Evaluation and Quality Control; by ASM International
4. Classroom Training Handbook Radiographic Testing (CT-6) –General Dynamics
5. Radiography in Modern Industry – 4th Edition Eastman Kodak Company
6. Nondestructive Testing Handbook – Radiographic Testing – Latest Edition ASNT
7. Can/CGSB 48.5-95 (48-GP-5M) Manual on Industrial Radiography
8. Industrial Radiography by GE Inspection Technologies
9. Personnel Training Publications, Radiographic Testing; by ASNT
10. Handbook of Nondestructive Evaluation, 2nd edition; by Chuck Hellier

Materials and processes

Although Materials & Processes (M&P) training is a prerequisite to all NDT training, method-specific M&P content is still a component of the NDT certification examinations. The following reference material may have been used to prepare examination questions:

1. Basic Metallurgy for Non-destructive Testing by BINDT
2. Materials and Processes for NDT Technology by ASNT
3. Non-destructive Testing Handbook , Introduction (PI-1) by PH Diversified
4. Metallurgy for the Non-Metallurgist. Second Edition by ASM International

NOTE: CAN/CGSB 48.9712:2022 section 7.2.3 states that “The minimum duration of training undertaken by the candidate for certification shall impart the skills and knowledge and shall not be less than that specified in 7.2.4 and Table 2 for the applicable NDT method.” Please refer to the NRCan NDTCB website for the minimum training requirements.

For RT, training hours do not include radiation safety training. Therefore, NRCan has implemented Radiation Safety Training Prerequisite for Radiographic Testing training.

Radiation Protection Paper:

1. Radiography in Modern Industry – 4th Edition Eastman Kodak Company
2. Gamma Radiography Safety Guide 2nd Edition
3. Can/CGSB 48.5-95 Manual on Industrial Radiography
4. Canadian Nuclear Safety Commission Act and Regulations
5. Health Canada Safety Code 34

Note: Most of the subjects covered by the General and A/S written examinations are found in the above publications; however, additional studying from other reference material may be useful.

Sample Questions: RT2 General Written Examination

1. A Cobalt 59 becomes a Cobalt 60 atom when it is placed in a nuclear reactor where its nucleus captures:
   a) an electron.
   b) a neutron.
   c) a proton.
   d) contamination.

2. Any action which disturbs the electrical balance of the atoms which make up matter is referred to as _____.
   a) attenuation.
   b) ionization.
   c) absorption.
   d) decay.

3. Two factors which greatly affect the suitability of the target material in an x ray generator are:
   a) tensile strength and yield strength.
   b) melting point and magnetic strength.
   c) electrical resistance and tensile strength.
   d) atomic number and melting point.

4. The smaller the physical dimensions of a gamma ray source:
   a) the greater the penetrating power of the gamma ray source.
   b) the less the penetrating power of the gamma ray source.
   c) the penetrating power of the gamma ray source does not depend upon the physical size.
   d) none of the above are true.

5. A device that uses an electron gun, magnetic fields, and a hollow circular tube (doughnut) in order to accelerate electrons in a circular path and to direct them to strike a target to give bursts of x rays is called a:
   a) Van de Graff Generator.
   b) betatron.
   c) resonance transformer.
   d) linear accelerator.

6. The projected area of the target as viewed parallel with the centre axis of the useful emergent beam of an x ray tube is called:
   a) focal spot.
   b) focus.
   c) effective (or apparent) focal spot.
   d) geometric unsharpness.

7. Subject contrast is affected by:
   a) thickness differences of the specimen.
   b) radiation quality.
   c) scattered radiation.
   d) all of the above.

8. The sharpness of the film image will improve if:
   a) the focal spot or physical size of the source is made larger.
   b) the object to film distance is increased.
   c) the film developing time is increased.
   d) a finer grain film is used.

9. When manually processing films, the purpose of sharply tapping hangers two or three times after the film have been lowered into the developer solution is to:
   a) disperse unexposed silver grains on the film surface.
   b) prevent frilling of the emulsion.
   c) dislodge any air bubbles clinging to the emulsion.
   d) minimize fogging.

10. As the development time increases:
   a) the characteristic curve grows steeper and moves to the left toward the density axis.
   b) the characteristic curve grows steeper and moves to the right toward the density axis.
   c) the characteristic curve remains the same in shape but moves to the left toward the density axis.
   d) there is little effect on the characteristic curve.

11. Wherever possible penetrameter placement is:
   a) on the source side of the specimen
   b) on the film side of the specimen
   c) over the thickest part of the specimen
   d) in the middle of the area of interest

12. The normal recording medium for autoradiography is the:
   a) microdensitometer
   b) xerographic plate
   c) radiographic film
   d) TV screen

Answer Key:

1. b	2. b	3. d	4. c	5. b	6. c
7. d	8. d	9. c	10. a	11. a	12. c

Sample Questions: RT2 A/S Written Examination

1. Assuming a factor of 1.0 for steel, what would be the equivalence in steel for 25 mm of copper if the equivalence factor for copper is 1.2?
    a) 0.8 mm
    b) 20.8 mm
    c) 30 mm
    d) 1.2 mm
2. What thickness of a flat type penetrameter (ASTM) would be used on a 35 mm material thickness for a 2.0% sensitivity?
    a) 0.35 mm
    b) 0.7 mm
    c) 7 mm
    d) 14 mm
3. What is meant by a "written procedure"?
    a) A set of rules, precepts and regulations.
    b) A method by which an experiment or task is carried out.
    c) A specific use of a nondestructive inspection method or other.
    d) A formula which defines a type of object, a product or a technical process for the purpose of simplifying production and making it more efficient and rational.
4. A rigid aircraft framework which may consist of bars, beams, rods, tubes and wires is a description of:
    a) a truss construction.
    b) a semi-monocoque construction.
    c) a monocoque construction.
    d) a cantilever construction
5. Integral wing skins are designed to offer maximum resistance to what kind of stress?
    a) Shear
    b) Compression
    c) Torsion
    d) Tension
6. In a damage tolerant structure:
    a) aircraft structures are heavier than in other systems such as "fail-safe" structures.
    b) there is no need to inspect at regular intervals except to check for damage/deterioration due to environmental conditions.
    c) the operational life of the aircraft is less than that of a "fail-safe" structure.
    d) damage to some extent during the service life can be tolerated as the structure does have a residual strength which will allow for sustaining satisfactory project loads until the damage is detected at regular inspections
7. The function(s) of the flux coating on the electrode is to:
    a) produce a gas that shields the arc from the atmosphere.
    b) add slag-forming properties and to control the cooling rate of the weld metal.
    c) both a) and b).
    d) melt the parent metal.

8. A material that has the ability to deform plastically without fracturing is said to be:
   a) work hardened
   b) plastic
   c) wrought
   d) ductile

9. A zinc or cadmium sulfide fluoroscopic screen which is continually exposed to bright daylight, sunlight, or other sources of ultraviolet radiation will:
   a) need to be recharged to regain its original fluorescence.
   b) become discolored and lose some of its brilliance.
   c) require a higher voltage setting of the x-ray generator to produce a satisfactory image.
   d) all of the above answers are correct.

10. Radiation scatter poses considerable problems when radiographing parts:
    a) which are uniformly thick and flat and make intimate contact with the radiographic film.
    b) which are flat but continuously vary in thickness or have large radius.
    c) which have built-in sections which in turn are well removed from the sections that make intimate contact with the film.
    d) both b) and c).

11. Aluminum sand castings are subject to:
    a) shrinkage cracks
    b) surface porosity and cold shuts
    c) micro-shrinkage
    d) all of the above

12. On a weld radiograph, a very thin, straight, dark line, either continuous or intermittent, located parallel to and normally on one side of a weld bead be indicative of:
    a) slag inclusion.
    b) burn through.
    c) aligned porosity.
    d) lack of fusion.

13. An extremely thin discontinuity that is the result of pipes, or inclusions flattened and made directional by working is called:
    a) a stringer.
    b) a lamination.
    c) a seam.
    d) a cold shut.

14. Intergranular corrosion:
    a) is caused by dissimilar metals in contact.
    b) is usually not detected until after the part has failed.
    c) is an attack on the grain boundaries of a metal.
    d) causes excessive surface pitting.

Answers

1. c	2. b	3. b	4. a	5. b	6. d	7. c	8. d
9. b	10. d	11. d	12. d	13. b	14. c		

Sample Questions: Levels 1, 2 & 3 Radiation Protection Examination

1. Geiger Mueller counters are used for radiation detection but are not recommended for industrial x-ray work because:
    a) the high intensity of radiation causes the batteries to saturate and not work
    b) high intensity radiation makes Geiger tubes brittle and fragile
    c) high intensity radiation may cause the Geiger tube to saturate and give a low measure or no measure of the true exposure rate
    d) high intensity radiation causes gas amplification by a factor of 10^{10} and this causes the Geiger tube to explode
2. An exposure rate of 5 mR/h is measured just outside the steel door to an xray room. The half value layer in lead for the transmitted x-rays is 0.09 cm. What thickness of lead would have to be added to the door to reduce the exposure rate to 1 mR/h?
    a) 0.21 cm
    b) 0.018 cm
    c) 2.25 cm
    d) 0.45 cm
3. The HVL of lead to control leakage from an x-ray tube operating at 200 kV is .4 mm. What thickness of lead would be required to reduce this leakage by a factor of 16?
    a) 0.4 mm
    b) 0.8 mm
    c) 1.6 mm
    d) 4.8 mm
4. Absorbed dose, no matter what its units are given in, is a measure of:
    a) energy deposited in a unit mass
    b) effective biological damage
    c) ionizations in a unit volume
    d) the product of a and b
5. The tenth value layer of lead for 250 kVp x-rays is 2.9 mm. What thickness of lead would be needed to reduce the exposure rate for this energy of radiation by a factor of 1000?
    a) 2,900 mm
    b) 0.25 mm
    c) 8.7 mm
    d) 87 cm
6. A person who receives a whole-body dose equivalent of 5 rems in one year:
    a) may develop radiation sickness
    b) should not have any medical x-rays
    c) will be unaffected
    d) may have an increased risk of cancer
7. For an uncontrolled area next to an x-ray room, the shielding should be sufficient to ensure that the maximum exposure is:
    a) 2.5 mR per week
    b) 10 mR per week
    c) 25 mR per week
    d) 100 mR per week

8. A counter placed 18cm from an energized x-ray tube reads 72,000 cpm (counts per minute). When measured at a new distance the reading is 44,100 cpm. What is the new distance?
   a) 21 cm
   b) 22 cm
   c) 23 cm
   d) 24 cm

9. In making an x-ray exposure, you find the dose rate at 2 meters from the x-ray tube is 1200 mR/h. What would be the dose rate at 8 meters?
   a) 75 mR/h
   b) 100 mR/h
   c) 200 mR/h
   d) 300 mR/h

10. The maximum annual whole-body dose that an x-ray worker is permitted to receive is:
   a) 5 millisieverts
   b) 50 millisieverts
   c) 500 millisieverts
   d) 5,000 millisieverts

11. An x-ray tube operating at 200 kVp and 4 mA is suitable for examining 1/4" thick steel pipe. What is the energy of the x-rays produced with this technique?
   a) 800 kVp
   b) 0.8 kVp
   c) up to 200 keV
   d) 0.8 MeV

12. Given the field at 2.5 m from an IR192 source is 2 µGy/hr, what distance could you approach before the field rose to 25 µGy/hr?:
   a) 0.21 m
   b) 0.50 m
   c) 0.67 m
   d) 0.71 m

13. Maximum annual dose limit for the public is:
   a) the same as NEW's
   b) 1/2 allowed a NEW
   c) 1/50 allowed a NEW
   d) 1/100 allowed a NEW

14. Given the HVL for 400 kV x-rays is 7.6 mm and a field of 10 Gy/hr. How many HVL of lead are needed to reduce the field to 1 Gy/hr?:
   a) 10
   b) 5.4
   c) 3.3
   d) 1.2

15. A dose equivalent of 50 millisieverts is equal to:
   a) 5 millirems
   b) 50 millirems
   c) 0.5 rem
   d) 5 rems

Answers

1. c	2. a	3. c	4. a	5. c	6. d	7. b	8. c
9. a	10. b	11. c	12. d	13. c	14. c	15. d	

General Information for the RT2 A/S Practical Examination

Prior to the attempting the practical examination, the candidate should be aware of the following:

1. The duration of the RT2 practical examination is a maximum of :
   - 20 hours (2½ days) if you are required to complete the General Practical portion (calibration exercises and performance test) of the examination (i.e. if *not* successfully completed at Level 1).
   - 16 hours (2 days) if you are *not* required to complete the General Practical portion of the examination (i.e. if successfully completed at Level 1).
2. The RT2 practical examination is a closed book examination. The following items are strictly **forbidden** and must be left outside the laboratory/examination room:
   - Books, notes and papers belonging to the candidate.
   - Electronic devices (cell phones, tablets, cameras, etc.).
   - Other items which could provide answers/information for examination questions/content or are capable of recording examination material.
3. The candidate is **not** allowed to bring their own equipment and the candidate is **not** allowed to take the examination documents, equipment or specimens out of the laboratory/examination room. All reporting must be completed within the laboratory/ examination room.
4. The candidate will be supplied with the necessary examination equipment and accessories as per NRCan NDTCB examination centre requirements, sufficient radiographic film of required speeds to carry out the techniques,all reporting sheets, any additional examination documents, and additional paper supplies (provided by the examination centre) as needed to complete the examination.
5. The candidate will be shown the safe operation and placement of equipment and accessories required to complete the examination. Candidates are advised to review the candidate instructions included with the examination documents.
6. The candidate will be shown the accessible surfaces of the test specimens and reference samples.
7. The candidate is expected to work within the safety requirements for radiography and the specific radiation safety protocols utilized at the examination centre.
8. The candidate will complete the practical exam specimen techniques and interpret the radiographs as indicated on the candidate's examination admittance and registration form, or from the Selection Table if applicable; the candidate may choose the order of the techniques.
9. The candidate may or may not be required to develop his/her own film. This decision will be made by the invigilator. Unless otherwise specified, the candidate has the choice of film types for inspection of the exam specimens.
10. Surface preparations are **not** permitted on the examination specimens. The candidate is requested to **not** mark the specimens, equipment and reference samples.
11. The candidate may ask questions concerning the examination. The invigilator may refuse to answer any questions that may be considered part of the examination requirements.
12. The candidate has the opportunity to provide feedback concerning the practical examination. After completing the examination, the candidate will complete the comment sheet and place it into the return envelope with the examination paper(s) prior to sealing the envelope. The comment sheet will then be sent to the NRCan NDTCB along with the examination in the sealed return envelope.

NOTE: If the candidate is operating unsafely or improperly while attempting their practical examination, it is the prerogative of the invigilator to discuss this situation with the candidate and, if necessary, terminate the practical examination. All such actions, as well as any special assistance given to the candidate, must be reported to the examiner on the invigilator's assessment sheet.

RT2 A/S Practical Examination Program

RT2 A/S Practical Examination Candidates shall complete the following:

1. General Equipment Check (only required if not successfully completed for RT level 1 certification)
   - Perform one (1) calibration test (Exposure curve)
2. Aerospace Practical Test
   - Inspect 4 specimens and prepare 4 techniques on aircraft structures/components using X-ray.

   The technique for each examination specimen must be completed in a manner that will permit a level 1 Radiographic inspector to follow your steps and duplicate your results.
3. Interpret 25 radiographs.
4. Create a detailed written instruction for one (1) of the inspected specimens.

General Examination Information:

1. Preparation of an Exposure Curve:

There are many types of exposure curves, and the candidate may choose any type for which they are familiar. The most popular curve is where thickness of material is plotted against exposure for specified kV. levels on semi log graph paper.

For exposure curves other than the ones plotted on semi log graph paper, the candidate may be required to supply his/her own graph paper.

The candidate will be given a sloped metal wedge, semi log graph paper and a blank data sheet.

The candidate will:

- take the exposures for the kV. energy designated by the invigilator;
- locate and clearly mark on the resulting radiographs where the required density (2.0) has been found and record the data; and
- plot the data points as derived from the radiographs and draw the exposure curve;.
- record all pertinent data specific to the equipment and parameters used.

Note: The plotted data points must be quite evident to the examiner.

2. Preparation and Development of Aerospace Radiographic Techniques:

The test will consist of four inspection areas. These will consist of different aircraft parts, each with an identified area of interest.

The candidate will be provided with:

- aircraft test samples
- film characteristic curves
- logarithmic and anti-logarithmic tables
- effective x-ray focal spot
- sketches of the test specimens
- exposure curves
- test sample identification/information which will highlight the area of interest

Cautionary Note:

After the candidate has and prepared the curve required in Part 1 of the exam, the candidate will be supplied with the appropriate exposure curves for this equipment. It should be noted that, although the Examination Centre supplies each candidate with exposure curves, it should not be assumed that the exposure curves are accurate for all the exam specimens. This is especially true for the light alloys. Following a test shot, the candidate is expected to have the necessary knowledge to quickly zero in on the correct exposures.

Coverage of the Exam Specimen:

The exam specimen will be inspected to 100% in the area of interest as identified by the technique identifier sheet.

3. Interpretation of Radiographs:

Instructions are provided with the radiographs to be interpreted.
When doing the interpretation portion, the following items are provided to the candidate:

- a variable high intensity viewer;
- interpretation sheets;
- a magnifying glass;
- a ruler and
- cotton gloves.

4. Written Instruction

Complete a written instruction for one of the specimens. The instruction must be written in a way that will enable another RT inspector to easily follow the steps and duplicate the results. It should include:

a) Foreword (scope of the inspection, reference documents, method used and field of application);
b) Personnel qualification requirements;
c) List of equipment and accessories used;
d) Product (description or drawing of the specimen, including area of interest and purpose of the test);
e) Test conditions, including preparation for testing and equipment calibration procedure;
f) Detailed instructions for the application of the test, including settings;
g) Recording and classifying of test results (report details);
h) Reporting the results (traceability).

Note: A candidate may use the general information accompanying the exam specimen for writing the instruction; however, the candidate must ensure to write a specific instruction to inspect the specific specimen.

General Technique Information:

The candidate should be allowed to repeat or take additional exposures in order that he/she may be satisfied with their radiographic technique. All film, both final and test exposures (if any), must be sent to the NDTCB.

The candidate will use the film available at the centre. The candidate may be required to load and develop his/her own film. **The film shall not be cut to fit specific exam specimens.**

The part should be considered a production part, therefore the cost of inspection due to the time involved and the number of films used, will be of importance.

Demonstration Aerospace Radiographic Technique

Radiographic techniques must contain all the testing parameters necessary for an individual with limited experience to duplicate your work and maintain the required level of inspection.

It is assumed that the recipient of the technique is someone who has limited knowledge of radiography. Therefore, the transfer of information from the candidate to the recipient must be clear, concise, neat and complete.

A comprehensive method of radiograph identification, relating each film to the technique, must be devised by the candidate.

General Safety Requirements

The candidate will be **observed** and may be graded on the general safety requirements of radiography namely; the use of a calibrated survey meter; wearing of a TLD/OSL; wearing of a DRD; as well as maintaining safe exposure perimeter barriers when not working within the confines of a radiographic exposure room.

Suggestions for Success: RT2 A/S Practical Examination

1. Ensure that you have sufficient experience and knowledge in RT inspection prior to booking your practical examination.

2. When you begin your practical examination, ensure that you **carefully read the examination instructions** prior to proceeding with the examination requirements.

3. Do not spend too much time on one section of the examination at the expense of the other sections. We suggest that you devote:
    - 1 hour to read instructions and familiarize yourself with the requirements and the equipment.
    - 2 hours to perform the exposure curve (if not certified at level 1).
    - 2.5 hours to inspect one (1) aircraft specimen.
    - 2.5 hours to inspect one (1) aircraft specimen.
    - 2.5 hours to inspect one (1) aircraft specimen.
    - 2.5 hours to inspect one (1) aircraft specimen.
    - 4 hours to interpret 25 radiographs.
    - 1 hour to write an NDT instruction for one (1) of the examination specimens

4. Ensure that you **fully inspect** the specimen and report **all reportable indications**.
5. Fill in the reporting sheets clearly, completely and concisely, ensuring that you show the correct size, shape, length and location of the indications, as accurately as possible on the illustrations provided in the reporting sheets (or if necessary, draw a sketch of a missing view).
6. The candidate is encouraged to utilize the prepared diagrams provided with the exam specimens. The candidate may draw additional views as required to produce a clearer and more complete technique; however, if the drawing of additional views causes the technique to lose clarity, the candidate may lose exam marks.
7. There are many different ways to radiograph an exam specimen. Grading of a technique will be according to the guidelines of coverage, density, sensitivity attained and clarity of the technique. The technique record must be written in a way that will enable a RT1 inspector to easily follow your steps and duplicate your results.
8. Do not hesitate to ask the invigilator questions. The invigilator may refuse to answer any question if it is considered part of the examination requirement.

Common Errors that may Result in Failure of the RT2 A/S Practical Examinations

1. Candidate not adhering to density limits as described in the standard supplied by the exam centre.
2. Candidate is unable to develop techniques within parameters of standard supplied by the test centre.
3. Candidate is unable to identify areas of interest on exam specimens and inspect for same.
4. Candidate is unable to produce a legible technique with sufficient information for a RT1 with limited experience to perform/achieve equal results.

Radiographic Testing Level 3

Radiographic Testing Level 3 (RT3) – Aerospace (AS) Sector Examination Scheme in Accordance with CAN/CGSB-48.9712

Examination Part	Pass Grade	Content	Duration
Basic Written Examination: Parts A, B and C (Unless successfully completed during other Level 3 method certification)	≥70% (on each part)	140 multiple choice questions (total) • Part A: ➢ 70 questions on general Materials & Processes (M&P) and discontinuities specific to welds, castings, wrought products, etc. • Part B: ➢ 10 questions on CAN/CGSB 48.9712 standard • Part C: ➢ 60 questions (15 questions per method) on 4 NDT methods selected by candidate.	4 hours
General Written Examination (Same as RT3 EMC General Exam)	≥70%	• 30 multiple choice questions on the theoretical principles of RT method.	1 hour
A/S – Codes and Applications Written Examination	≥70%	• 35 multiple choice questions (total) ➢ 5 questions on codes (worth 2pts each) ➢ 30 questions on RT applications and techniques	1 ¾ hours
Written Procedure[1] **or** Written Procedure Review[2]	≥70%	• Write one NDT procedure (required for first Level 3 certification). • Option to instead review an NDT procedure (for each additional Level 3 method certification)	4 hours **or** 1½ hours
A/S Practical Examination (If not successfully completed at Level 2)[3]	≥70% (on each specimen/subpart)	• Same as level 2 examination	16 **or** 20 hours

[1] **Written Procedure:**

This four-hour examination must be completed by candidates seeking their first Level 3 method certification.

- To complete this examination, the candidate will write a method-specific NDT procedure.
- Writing a comprehensive NDT procedure that meets industrial standards may typically take several days to complete; the NDT Certification Body therefore provides Level 3 candidates (upon application approval) with a pre-examination package that includes all the information and details necessary to prepare for this examination.

[2] **Written Procedure Review:**

Candidates seeking a subsequent Level 3 method certification have the option of completing a 1½ hour procedure review examination, instead of writing another procedure examination.

- To complete this examination, the candidate will review a sample procedure that he/she is to assume comes from their staff for review and approval.
- The candidate (as the responsible Level 3 individual/supervisor) must review the procedure and identify the mistakes and deficiencies; the candidate will record the mistakes and deficiencies directly in the procedure, adjacent to the problem area. (An example of this will be shown in the procedure review examination document.)
- The candidate must identify and report as many problem areas or deficiencies as they can find within the procedure document. Deficiencies may include, but are not limited to the following:
  - no cover sheets, no provision for approval signatures, approval signatures by unauthorized personnel, missing or incorrect information in headers, missing attachments/references, missing sections, incorrect paragraph numbering, contradicting technical data, technical data contrary to good practice, unclear statements, inconsistent formatting of the document, information placed in wrong sequence, typographical errors, etc.

[3] **Practical Examination:**

Candidates seeking direct access to Level 3 certification must successfully complete the Level 2 method-specific practical examination with a grade of ≥70 %.

- A candidate who is Level 2 in the same NDT method and product sector or who has successfully passed a Level 2 practical examination for the same NDT method and product sector is exempt from the Level 2 practical examination.
- Please refer to the General Information for the RT2 A/S Practical Examination and the RT2 A/S Practical Examination Program.

Reference Material for RT3 A/S Written Examination Preparation

General and A/S Examinations

1. Aircraft Maintenance and Repair, by Delp/Bent/McKinley
2. Advisory Group for Aerospace Research & Development by AGARD-AG-201-Vol.1
3. ASM Metals Handbook – Volume 17; by ASM International
4. Classroom Training Handbook Radiographic Testing (CT-6) –General Dynamics
5. Radiography in Modern Industry – 4th Edition Eastman Kodak Company
6. Nondestructive Testing Handbook – Radiographic Testing – Latest Edition ASNT
7. Can/CGSB 48.5-95 (48-GP-5M) Training Manual on Industrial Radiography
8. Industrial Radiography by GE Inspection Technologies
9. Personnel Training Publications, Radiographic Testing; by ASNT
10. Handbook of Nondestructive Evaluation, 2nd edition; by Chuck Hellier

Materials and Processes

Although Materials & Processes (M&P) training is a prerequisite to all NDT training, method-specific M&P content is still a component of the NDT certification examinations. The following reference material may have been used to prepare examination questions:

1. Basic Metallurgy for Non-destructive Testing by BINDT
2. Materials and Processes for NDT Technology by ASNT
3. Non-destructive Testing Handbook , Introduction (PI-1) by PH Diversified
4. Metallurgy for the Non-Metallurgist. Second Edition by ASM International

NOTE: CAN/CGSB 48.9712:2022 section 7.2.3 states that “The minimum duration of training undertaken by the candidate for certification shall impart the skills and knowledge and shall not be less than that specified in 7.2.4 and Table 2 for the applicable NDT method.” Please refer to the NRCan NDTCB website for the Minimum training requirements.

For RT, training hours do not include radiation safety training. Therefore, NRCan has implemented Radiation Safety Training Prerequisite for Radiographic Testing training.

Radiation Protection Paper:

1. Radiography in Modern Industry – 4th Edition Eastman Kodak Company
2. Gamma Radiography Safety Guide 2nd Edition
3. Can/CGSB 48.5-95 Manual on Industrial Radiography
4. Canadian Nuclear Safety Commission Act and Regulations
5. Health Canada Safety Code 34

Basic Examination (Parts A, B & C)

1. Materials and Processes for NDT Technology, By ASNT
2. Basic Metallurgy for Non-destructive Testing, By British Institute of NDT
3. Why Metals Fail, chapter 2, By R.D. Barer and B.F. Peters
4. Manufacturing Processes, By Vernon L. Stokes
5. Qualification and Certification of Non-destructive Testing Personnel CAN/CGSB - 48.9712

Note: Candidates should familiarize themselves with the capabilities and limitations of other NDT methods when preparing for the Basic Written Examination.

Written Procedure Examination

As indicated in the RT3 A/S examination scheme (above), the candidate will be provided with (at the time of application) a pre-examination package that includes all the information and details necessary to prepare for the examination.

Note: Most of the subjects covered by the Level 3 written examinations are found in the above publications; however, additional studying from other reference material may be useful.

Sample Questions: RT3 General Written Examination

1. Radium:
    a) is a daughter product of radon.
    b) has a very short half-life.
    c) an artificially made isotope.
    d) a metallic element.

2. High energy photons of 1.02 MeV or greater typically interact with matter by which one of the following:
    a) photoelectric process.
    b) Compton scattering process.
    c) pair production process.
    d) photodisintegration process.

3. An anode in which the target is located at the bottom of an opening, or a "pocket" is frequently used in industrial x-ray tubes for improving the distribution of the high voltage field. This type of anode is referred to as a:
    a) rotating anode.
    b) hot anode.
    c) hooded anode.
    d) line-focus anode.

4. Cobalt 59:
    a) is an element different than that of Cobalt 60.
    b) transforms to Cobalt 60 after capturing a neutron.
    c) emits gamma radiation which is of different energies than Cobalt 60.
    d) both a) and b) are correct.

5. Which is not an advantage of a linear accelerator for producing x-rays?
    a) low cost
    b) high radiation output
    c) small focal spot dimensions
    d) light weight

6. Fluoroscopic screens of zinc cadmium sulfide find occasional use in industrial applications. These screens normally are not subject to wear or deterioration from exposure to long term x-rays. Which one of the following will severely degrade this type of screen?
    a) Cleaning of the screen with grain alcohol
    b) Prolonged storage in a low humidity environment will cause the crystal to hydrolyze
    c) Exposure to ultraviolet radiation sources
    d) Contamination with nickel, as little as one part per million will create severe afterglow problems

7. The intensity of a monoenergetic radiation after passing through a material may be calculated by the formula $I = I_0 e^{-\mu t}$. This formula does not take into account:
    a) linear absorption.
    b) scattered radiation.
    c) half value layer thickness.
    d) attenuation.

8. Radiographic image magnification by placing the film at a distance from the object is practical when using linatrons and betatrons because:
    a) natural magnification occurs with high energy x-rays
    b) of their large beam spread
    c) of the small focal spot size
    d) high energy x-rays have such short wavelengths

9. Radiographic image quality may be adversely affected by poor subject contrast; this may be caused by:
    a) insufficient absorption differences in the specimen.
    b) excessive radiation energy for the application.
    c) unwanted and excessive scatter.
    d) all of the above.

10. The primary reason(s) why sight (under safelight conditions) development of radiographs should be avoided is:
    a) it is difficult to discern the image with the light output provided by a safelight.
    b) the appearance of a developed but unfixed radiograph will be different when compared with properly finished film.
    c) removal of the film from the developer will affect the development time.
    d) film speed changes when exposed to a safelight.

11. Wire penetrameters are most commonly used in _____ codes.
    a) AFNOR
    b) ASME
    c) ASTM
    d) DIN

12. Generally, the sensitivity and accuracy of thickness gauging of homogeneous materials by reflection methods is:
    a) superior to transmission gauging.
    b) superior to fluorescence methods.
    c) inferior to transmission gauging.
    d) approximately the same as with transmission gauging.

Answer Key:

1. d	2. c	3. c	4. b	5. a	6. c	7. b	8. c
9. d	10. b	11. d	12. c				

Sample Questions: RT3 Aerospace Codes and Applications Written Examination

1. A tenth value thickness for a specific gamma source is 25 mm of lead. The radiation intensity is 20 R/min from the source. How many mm of lead would be required to reduce the intensity to 1.2 mR/hr?
    a) 150 mm
    b) 110 mm
    c) 30 mm
    d) 28 mm

2. Cobalt 60 is reported to have a half-life of 5.3 years. By how much should exposure time be increased (over that used initially to produce excellent radiographs when the cobalt 60 source was new) when the source is two years old?
    a) No change in exposure time is needed
    b) Exposure time should be about 11% longer
    c) Exposure time should be about 37% longer
    d) Exposure time should be from 62 to 100% longer

3. If a radiograph shows the 2T hole and outline of a .5 mm thick penetrameter, the 2-2T quality level is attained on a specimen:
    a) 25 mm thick.
    b) 50 mm thick.
    c) 12 mm thick.
    d) none of the above.

4. A "bulkhead" on an aircraft can be defined as:
    a) a large container used to carry cargo in transport aircraft.
    b) the area directly above the pilot and co-pilot where all the control switches are located.
    c) the leading edge of the stabilizers.
    d) the vertical structure members which carry the major structural loads in the fuselage.

5. Which of the following is a classification of wing flaps:
    a) a vertical flap.
    b) a horizontal flap.
    c) a negative flap.
    d) a positive flap.

6. An example of a "Combination Control Surface" is:
    a) a Rudderon.
    b) an Aerator.
    c) a Flaperon.
    d) all of the above.

7. Which of the following is an example of a "Metal Spar" used on aircraft?
    a) Built-up Double Web.
    b) Laminated.
    c) Built-up S
    d) Built-up J

8. All types of Rotary Wing aircraft have two rotors. Some have two main rotors, and some have one main rotor and one tail rotor. One purpose of the tail rotor on a helicopter is to:
   a) add lift to the helicopter.
   b) control the yaw of the helicopter.
   c) assist in turning the helicopter to the left or right.
   d) none of the above.

9. If an isotope of Ir-192 was measured to be 20 curies on July 7, 1990, when would it have been 222 curies?
   a) 200 days ago
   b) 222 days ago
   c) 254 days ago
   d) 283 days ago

10. The most efficient and cost-effective means of reducing the effects of scattered radiation on a film is:
   a) masks
   b) lead screens
   c) filters
   d) collimators

11. Images of discontinuities close to the source side of the specimen become less clearly defined as:
   a) source-to-object distance increases.
   b) the thickness of the specimen increases.
   c) the size of the focal spot decreases.
   d) the thickness of the specimen decreases.

12. If the water used to make up the developer, the fixer or the water for the final rinse is too hard, the result will be:
   a) grey fogging.
   b) yellow fogging.
   c) dichroic fogging.
   d) white streaks.

13. The shape of the film characteristic curve is relatively insensitive to changes in X or gamma radiation quality but is affected by changes in the:
   a) geometric factors.
   b) shape and type of material of the specimen.
   c) subject contrast.
   d) degree of development.

Answer Key:

1. a	2. c	3. a	4. d	5. c	6. c	7. a	8. b
9. c	10. b	11. b	12. d	13. d			

Sample Questions: Level 3 Basic Written Examination

1. The Canadian standard for the certification of non-destructive testing personnel is developed and maintained by:
    a) the Canadian General Standards Board (CGSB).
    b) a standard committee composed of representatives from industry working under the auspice of CGSB.
    c) Natural Resources Canada under the auspice of the Canadian General Standards Board.
    d) a cooperative effort between various Canadian regulatory bodies and Natural Resources Canada.

2. The levels of certification covered by the CGSB standard on NDT personnel certification are:
    a) trainee, Level 1, Level 2, Level 3.
    b) apprentice, trainee, Level 1, Level 2, Level 3.
    c) Level 1, Level 2, Level 3.
    d) none of the above.

3. The pickling time will be least for:
    a) low carbon steel.
    b) high carbon steel.
    c) alloy steels.
    d) pickling time is the same for all three materials.

4. Which of the following may be considered an advantage of powder metallurgy as a manufacturing method?
    a) Production of parts of closer tolerances
    b) Mass production of hard to shape parts
    c) Produce parts with a high strength to weight ratio
    d) All of the above

5. Which of the following heat treatments usually follows a hardening treatment in order to make the steel more ductile?
    a) Annealing
    b) Tempering
    c) Spheroidizing
    d) Normalizing

6. Which of the following statements is correct?
    a) Alkaline solutions are never used to clean aluminum alloys.
    b) Acid solutions are never used to clean aluminum alloys.
    c) Acid solutions are usually used to clean aluminum alloys.
    d) Alkaline solutions are usually used to clean aluminum alloys.

7. Suitable combinations of two different materials each with specific properties may result in a composite that:
    a) is better in terms of resistance to heat than either of the two components alone.
    b) is stronger in tension per unit weight than either of the two components alone.
    c) is stiffer per unit weight than either of the two components alone.
    d) any of the above.

8. The practical length standards used by industry for gauging are:
   a) angle slip gauges.
   b) sine bars.
   c) wavelengths of light emitted by different elements.
   d) gauge blocks.

9. Thermal conductivity of a metal is an important factor to consider in making quality weldments because:
   a) some metals, such as aluminum, have a low conductivity which results in weld defects due to localized heat build-up.
   b) some metals, such as stainless steel, have a high conductivity which results in lack of fusion defects as the heat is quickly removed from the weld zone.
   c) in some metals, such as aluminum, very high temperature gradients are produced, causing stresses during cooling.
   d) none of the above.

10. Fracture is a type of material failure. Of the following, which is another type of material failure?
   a) Fracture mechanics
   b) Low frequency dynamic loading
   c) Permanent deformation
   d) Elongation within the elastic range

11. To remove iron from the ore in a blast furnace, the following materials are added to the furnace to generate the desired chemical reactions:
   a) coke, ore and oxygen.
   b) bauxite, ore and air.
   c) coke, ore, limestone and air.
   d) coke, ore, limestone and bauxite.

12. The reason for putting ingots in a soaking pit is:
   a) to control the direction of crystallization.
   b) to homogenize the structure and composition of the ingots.
   c) to permit slow cooling of the ingots.
   d) to bring them to the temperature required for rolling.

13. An advantage of using green sand molds over dry sand molds is:
   a) green sand molds are stronger than dry sand molds and thus are less susceptible to damage in handling.
   b) surface finish of large castings is better when using green sand molds.
   c) Over-all dimensional accuracy of the mold is better with green sand.
   d) there is less danger of hot tearing of castings when using green sand molds.

14. Shielded metal arc welding is a process of joining metals which is:
   a) fully automated.
   b) semi-automated.
   c) carried out manually.
   d) all of the above.

15. In the resistance spot welding of low carbon steel the heat generated is:
   a) concentrated between the positive electrode and the work.
   b) concentrated at the interface of the two plates to be welded.
   c) concentrated between the negative electrode and the work.
   d) evenly distributed in the work between the electrodes.

16. Which of the following is not a brazing process?
    a) Furnace brazing
    b) Induction brazing
    c) Infrared brazing
    d) Electron beam brazing

17. Completely recrystallized hot rolled steel products have:
    a) exactly the same mechanical properties in the longitudinal and transverse directions.
    b) superior mechanical properties in the direction of rolling.
    c) superior mechanical properties in the transverse direction.
    d) inferior mechanical properties than the original cast structure.

18. Care must be taken not to splash steel on the walls of the mold when pouring to prevent formation of surface defects like:
    a) inclusions.
    b) seams.
    c) cold shots.
    d) bursts.

19. Bursts are caused by:
    a) casting at too low a temperature.
    b) forging metal which is either too hot or too cold.
    c) insufficient reduction in size is attempted in one forging operation.
    d) none of the above.

20. Slag inclusions in welds are caused by:
    a) wide weaving.
    b) incomplete de-slagging of a previous pass.
    c) moisture entrapped in the joint.
    d) both a) and b).

21. Cobalt 60 is reported to have a half-life of 5.3 years. By how much should exposure time be increased (over that used initially to produce excellent radiographs when the cobalt 60 source was new) when the source is two years old?
    a) no change in exposure time is needed.
    b) exposure time should be about 11% longer.
    c) exposure time should be about 37% longer.
    d) exposure time should be from 62 to 100% longer.

22. In ultrasonics, increasing the length of the pulse to activate the search unit will:
    a) decrease the resolving power of the instrument.
    b) increase the resolving power of the instrument.
    c) have no effect on the test.
    d) will decrease the penetration of the sound wave.

23. Optimum magnetic particle inspection of a 50 mm inside diameter gear containing a keyway would require:
    a) circular method with magnetic field parallel to keyway.
    b) circular method with magnetic field perpendicular to keyway.
    c) using central conductor.
    d) all of the above.

24. Which of the following physical properties, more than any other, determines what makes a material a good penetrant?
    a) viscosity.
    b) surface tension.
    c) wetting ability.
    d) no one single property determines if a material will or will not be a good penetrant.

25. Direct current saturation coils would most likely be used when testing _____ by the eddy current method.
    a) steel
    b) aluminum
    c) copper
    d) brass

Answer Key:

1. b)	2. c)	3. c)	4. d)	5. b)	6. d)	7. d)	8. d)
9. d)	10. c)	11. c)	12. d)	13. d)	14. c)	15. b)	16. c)
17. b)	18. c)	19. b)	20. d)	21. c)	22. a)	23. d)	24. d)
25. a)							