Radiographic Testing

Examination Guide for Initial Certification

Engineering, Materials and Components Sector

Canada

Contact Information

National Non-Destructive Testing Certification Body
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Ce guide est aussi disponible en français à l'adresse suivante :

Organisme de certification national en essais non destructifs
CanmetMATÉRIAUX
Ressources naturelles Canada
183 chemin Longwood Sud
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Table of Contents

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 form 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/sub-part 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, 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) Ginzel Bros. NDT Testmaker 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 1

Radiographic Testing Level 1 (RT1) - Engineering, Materials and Components (EMC) Sector Examination Scheme in Accordance with CAN/CGSB-48.9712

Examination Part	Pass Grade	Examination Content	Duration
General Written Examination	≥70%	• 40 multiple choice questions on the theoretical principles of RT.	1 hour & 20 minutes
EMC (Specific) Written Examination	≥70%	• 40 multiple choice questions (total) ➢ 15 questions on discontinuities, their names, locations and appearances, detectable by RT. ➢ 25 questions on RT applications and techniques.	2 hours
Radiation Protection Paper	≥70%	• 25 multiple choice questions applicable to radiation safety	1 hour
Practical Examination	≥70% (on each specimen/subpart)	• General Equipment Check ➢ Produce an exposure curve 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. • Inspect 2 specimens, according to written instructions.	4 hours

Reference Material for RT1 EMC Written Examination Preparation

General and EMC Examinations

1. Classroom Training Handbook Radiographic Testing (CT-6-6) –General Dynamics
2. Radiography in Modern Industry – 4th Edition Eastman Kodak Company
3. Volume 17 Nondestructive Evaluation and Quality Control; by ASM International
4. Nondestructive Testing Handbook – Radiographic Testing – Latest Edition ASNT
5. Can/CGSB 48.5-95 (48-GP-5M)
6. Industrial Radiography by GE Inspection Technologies
7. Personnel Training Publications, Radiographic Testing; by ASNT
8. 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-4-1) by General Dynamics
4. Metallurgy for the Non-Metallurgist. Second Edition by ASM International

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

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. NRCan has implemented a 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 Training Manual on Industrial Radiography
4. Canadian Nuclear Safety Commission Act and Regulations
5. Health Canada Safety Code 34

It should be noted that additional studying from other books might be useful. Candidates shall possess the prerequisite in Math Skills and Materials & Processes knowledge prior to method specific training.

Sample Questions: RT1 General Written Examination

1. The essential parts of an atom are:
   a) proton, positron, electron.
   b) proton, electron, gamma ray.
   c) photon, electron, neutron.
   d) proton, electron, neutron.

2. Primary radiation is:
   a) all radiation incident on a radiographic film.
   b) radiation arising directly from a radioactive source.
   c) radiation arising directly from the target of an x-ray tube.
   d) b) and c) are true.

3. X-rays emitted from the focal spot on the tungsten target of an x-ray tube:
   a) is focused downward by the angle of the tungsten target.
   b) is deflected downward by the angle of the tungsten target.
   c) is made up of high-speed electrons which are deflected downward by the angle of the focal spot.
   d) travels in straight lines in the form of a diverging conical beam from the focal spot.

4. Intensity of a radiographic source, measured in becquerels, plotted against time is known as a:
   a) calibration curve
   b) decay curve.
   c) exposure chart.
   d) density gradient.

5. Alpha radiation is a form of:
   a) gamma radiation.
   b) electromagnetic radiation.
   c) particulate radiation.
   d) x-ray radiation.

6. In general, which of the following is correct for fluorescent intensifying screens?
   a) longer exposure and poor radiographic definition.
   b) shorter exposure and poor radiographic definition.
   c) shorter exposure and improved radiographic definition.
   d) shorter exposure and clear radiographic definition.

7. A material used to surround or is inserted into an object during radiography to reduce the effect of unwanted scattered radiation is known as:
   a) collimating material.
   b) filtering material.
   c) refracting material.
   d) blocking material.

8. The sharpness of the outline of the radiographic image will improve (that is less fuzzy) if:
   a) the focal spot of x-ray tube or the physical size of the gamma source is increased.
   b) the source to film distance is increased.
   c) the film developing time is increased.
   d) a coarse grain film is used.

9. The density difference between two adjacent areas of a radiograph is known as:
   a) unsharpness.
   b) radiographic contrast.
   c) relative density of the specimen.
   d) subject density.

10. A penetrameter (or an image quality indicator, IQI) is used in radiography to indicate:
   a) radiographic film sensitivity.
   b) the size of the smallest detectable defect.
   c) radiographic film density.
   d) radiographic film contrast.

11. Another term for real-time radiography could be:
   a) flash radiography.
   b) xeroradiography.
   c) fluoroscopy.
   d) autoradiography.

12. The selection of a suitable radiographic film to be used for the x-ray examination of a particular part depends on:
   a) the thickness of the specimen.
   b) the density of the specimen.
   c) the kilovoltage range available on the x-ray machine.
   d) all three of the above stated factors.

13. During the development stage of the radiographic film processing, it is important to observe the time temperature relationship recommended by the manufacturers of the chemicals. However, if the time is kept constant (i.e. the same as the one recommended) and the temperature of the developing solution is reduced below the recommended figure it will result in:
   a) overdeveloped radiographic film.
   b) underdeveloped radiographic film.
   c) fogging of the radiographic film.
   d) damaging of the radiographic film due to the frilling.

14. "Inherent graininess" refers to the dispersal of the silver halide crystals in the emulsion of the unexposed radiographic film. This inherent graininess of the radiographic film will affect:
   a) contrast.
   b) sensitivity.
   c) density
   d) a), b) and c).

15. The amount of film darkening in radiography is given the term:
   a) transmittance
   b) opacity
   c) density
   d) percent transmittance

Answers

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

Sample Questions: RT1 EMC Written Examination

1. The duty cycle of an x-ray tube is a measure of:
   a) the maximum kilovoltage that can be applied to the tube.
   b) the maximum filament current that can be applied.
   c) the amount of time the tube must rest between exposures.
   d) the amount of time required to warm up the tube before the first exposure of the day.

2. The normal range of steel radiographed using IR-192 is:
   a) 5mm to 25 mm
   b) 25mm to 75mm
   c) 5mm to 100mm
   d) 45mm to 200mm

3. Of the following choices, indicate the most appropriate. In order to decrease exposure time, a radiographer might:
   a) use lead intensifying screens.
   b) increase the focal film distance.
   c) process at lower chemical temperatures.
   d) use a copper filter at the window of the x-ray tube.

4. Primary radiation which strikes a film holder or cassette through a thin portion of the specimen will cause scattering into the shadows of the adjacent thicker portions producing an effect called:
   a) radiation imaging.
   b) spotting.
   c) undercut.
   d) unsharpness.

5. Filters placed between the source of radiation and the specimen (or object) tend to reduce scatter radiation undercutting the specimen by:
   a) absorbing the longer wavelength components of the primary beam.
   b) absorbing the shorter wavelength components of the primary beam.
   c) absorbing backscatter radiation.
   d) decreasing the intensity of the beam.

6. A general rule often employed for determining the kilo-voltage to be used when x-raying a part is:
   a) the kilovoltage should be as high as other factors will permit.
   b) the kilovoltage should be as low as other factors will permit.
   c) the kilovoltage is always a fixed value and cannot be changed.
   d) the kilovoltage is not an important variable and can be changed over a wide range without affecting the radiograph.

7. The name of the defect which is most likely to occur at the junction of light and heavy sections is:
   a) porosity
   b) hot tear
   c) blow hole
   d) both a) and c)

8. Oval or circular dark spots with smooth edges appearing on weld or casting radiographs would most probably be indicative of:
   a) burn through.
   b) crater crack.
   c) porosity.
   d) lack of fusion.

9. Where on a forged piece can you find a burst?
   a) inside the piece
   b) always on the surface of the piece
   c) on the surface of the piece
   d) answers a) and c) are correct

10. Which defect results in damage to surfaces in contact, especially in a corrosive environment?
    a) stress corrosion crack
    b) embrittlement
    c) fretting corrosion
    d) intergranular corrosion

Answer Key:

1. c	2. b	3. a	4. c	5. a	6. b	7. b	8. c
9. d	10. 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/hr (50 µSv/hr) is measured just outside the steel door to an x-ray 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/hr (10µSv/hr)?
   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 (50mSv) 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 (0.025 mSv) per week
    b) 10 mR (0.1 mSv) per week
    c) 25 mR (0.25 mSv) per week
    d) 100 mR (1 mSv) per week

8. A counter placed 18 cm 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/hr. What would be the dose rate at 8 meters?
    a) 75 mR/hr
    b) 100 mR/hr
    c) 200 mR/hr
    d) 300 mR/hr

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 limits public is:
    a) the same as nuclear energy worker (NEW)
    b) 1/2 allowed an NEW
    c) 1/50 allowed an NEW
    d) 1/100 allowed an 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

Answer Key:

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 RT1 EMC Practical Examination

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

1. The duration of the RT1 practical examination is a maximum of 4 hours (1/2 day).

2. The RT1 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, as well as 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 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 is expected to work within the safety requirements for radiography and the specific radiation safety protocols utilized at the examination centre.

7. The candidate will complete the practical exam specimens 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. If, for any reason, the candidate must deviate from the supplied technique, the circumstances for this deviation must be stated and supported by the invigilator.

8. No surface preparations are permitted on the exam specimens; they must be used as is. The candidate is requested not to mark the equipment, exam specimens or reference material.

9. The candidate may or may not be required to load and develop their film. This decision will be made by the invigilator.

10. The candidate may ask questions concerning the examination. An invigilator may refuse to answer any questions that may be considered part of the examination requirements.

11. 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.

RT1 EMC Practical Examination Program

RT1 EMC Practical Examination Candidates shall complete the following:

1. General Equipment Check
   Prepare an exposure curve according to instructions.
2. EMC Practical Test:
   - Inspect a welded specimen according to written instructions.
   - Inspect a metal formed specimen according to written instructions.

General Examination Information:

1. Preparation of an Exposure Curve:

There are many types of exposure curves, and the candidate may choose any type with 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 their 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. Coverage of the Exam Specimens

The limits of coverage will be indicated in the technique provided. The candidate will produce results as indicated by the technique. Upon completion of the two techniques **all** film, both used and unused, will be handed in to the invigilator along with the specimen techniques. **NO** paper or film is allowed to leave the exam centre.

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 an 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: RT1 EMC 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:
   - 15 minutes to read instructions and familiarize yourself with the requirements and the equipment.
   - 1 3/4 hours to conduct the exposure curve .
   - 1 hour to inspect a welded specimen .
   - 1 hour to inspect a metal formed specimen.
4. You may ask questions concerning the examination however, the invigilator may refuse to answer any question if it is considered part of the examination requirements.

Common Errors that may Result in Failure of the RT1 Practical Examinations

1. Candidates not following the provided technique.
2. Candidates not having sufficient experience or knowledge of RT inspection.
3. Candidates missing detailed information for the exposure curve. .

Radiographic Testing Level 2

Radiographic Testing Level 2 (RT2) - Engineering, Materials and Components (EMC) Sector Examination Scheme in Accordance with CAN/CGSB-48.9712

Examination Part	Pass Grade	Examination Content	Duration
General Written Examination	≥70%	• 40 multiple choice questions on the theoretical principles of RT	1 hour & 20 minutes
EMC (Multi-sector) Written Examination	≥70%	• 70 multiple choice questions (total) ➢ 30 questions on materials & processes and discontinuities detectable by RT. ➢ 10 questions on codes (worth 4 marks each). ➢ 30 questions on RT applications and techniques.	3 ½ hours
Radiation Protection Paper	≥70%	• 25 multiple choice questions applicable to radiation safety	1 hour
Practical Examination (Multi-sector)	≥70% (on each specimen/subpart)	• General Equipment Check (only required if not level 1 certified) ➢ Produce an exposure curve 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. ➢ Using gamma ray for one (1) weld ➢ Using x-ray for - One (1) weld - One (1) light alloy - One (1) heavy metal casting or forging • Interpretation of 26 radiographs • Detailed written instruction for one (1) of the inspected specimens.	16 hours

Reference Material for RT2 EMC Written Examination Preparation

General and EMC Examinations

1. Classroom Training Handbook Radiographic Testing (CT-6-6) –General Dynamics
2. Radiography in Modern Industry – 4th Edition Eastman Kodak Company
3. Volume 17 Nondestructive Evaluation and Quality Control; by ASM International
4. Nondestructive Testing Handbook – Radiographic Testing – Latest Edition ASNT
5. Can/CGSB 48.5-95 (48-GP-5M)
6. Industrial Radiography by GE Inspection Technologies
7. Personnel Training Publications, Radiographic Testing; by ASNT
8. 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 Training Manual on Industrial Radiography
4. Canadian Nuclear Safety Commission Act and Regulations
5. Health Canada Safety Code 34

Codes and Standards

The following five codes/specifications/techniques were utilized to draft the RT2 EMC examination questions on codes. New codes/questions may be added periodically.

It is not recommended that candidates purchase these publications, but rather they familiarize themselves with the general layout of codes and standards.

1. CSA Z184-M
2. ASTM E 1025 Hole Type Image Quality Indicators Used for Radiography
3. Military Standard Inspection Radiographic MIL-STD-453C
4. MIL-1-6865 (ASG)
5. ASTM E 94 - Standard Practice for Radiographic Testing

Note: Most of the subjects covered by the General ,EMC and Radiation Protection 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 EMC Written Examination

1. What is the radiation dose at 4 meters from a source when the radiation is 20 mSv at 1 metre is:
   a) 1.25mSv.
   b) 5mSv.
   c) 80mSv.
   d) 160 mSv

2. Given 100 GBq of Co 60 (half-life 5.3 years), what amount of time elapses before it is only 22 GBq?
   a) 10.2 years
   b) 10.9 years
   c) 11.1 years
   d) 11.6 years

3. The penetrating ability of an x ray beam is greatest for which of the following wavelengths:
   a) 0.1nm.
   b) 9.0nm.
   c) 100.0nm.
   d) 3.0 nm.

4. A Cobalt 60 gamma ray source has an approximate practical thickness limit in steel of:
   a) 62 mm (2.5 in).
   b) 100 mm (4.0 in).
   c) 185 mm (7.0 in).
   d) 275 mm (12.0 in).

5. If a specimen were radiographed at 40 kV and again at 50 kV with time compensation to give the radiographs the same density, which of the following statements would be true?
   a) The 40 kV exposure would have a lower contrast and greater latitude than the 50 kV exposure
   b) The 40 kV exposure would have a higher contrast and greater latitude than the 50 kV exposure
   c) The 50 kV exposure would have a lower contrast and greater latitude than the 40 kV exposure
   d) The 50 kV exposure would have a higher contrast and greater latitude than the 40 kV exposure

6. Which is not an advantage of paper radiography?
   a) speed of access
   b) viewing of densities greater than film
   c) good image quality
   d) portability and economy

7. What must the direction of applied stress be to result in lamellar tearing?
   a) Parallel to the rolling direction of the plate
   b) Perpendicular to the rolling direction of the plate
   c) 45N to the rolling direction of the plate
   d) All of the above

8. Since rolling results in the flattening and elongation of a sheet of metal, what happens to a pocket of gas in a metal sheet as a result of hot rolling?
   a) It is still present and is the same size.
   b) It is still present, and it grows.
   c) It is still present but is larger in size.
   d) None of the above answers.

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

10. Hot tears generally originate:
   a) internally or at the surface
   b) from a large pore
   c) from internal chaplets
   d) from flat areas

11. Under-bead cracking occurs in the:
   a) root pass of a weld
   b) heat affected zone of a weld
   c) second last layer of weld passes
   d) crater at the end of a weld bead

12. In a shielded metal arc weld, entrapped gas pockets that are aligned and separated by a relatively small distance is called:
   a) piping porosity
   b) linear porosity
   c) pitting
   d) straight porosity

13. Which of the following is not a discontinuity common to forged products?
   a) Laps
   b) Shrinkage
   c) Bursts
   d) Flakes

14. Fine lines, likely to occur in groups caused by non-metallic impurities present in the original ingot and extruded lengthwise are called:
   a) stringers.
   b) seams.
   c) laminations.
   d) laps.

15. Is there a difference between a corrosion fatigue crack and intergranular corrosion in terms of the grain of the metal?
   a) No, as these two defects are transgranular
   b) No, as these two defects are intergranular
   c) Yes, as a corrosion fatigue crack is trans-granular and intergranular corrosion is intergranular
   d) Yes, as a corrosion fatigue crack is intergranular and intergranular corrosion is transgranular

Answer Key:

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

General Information for the RT2 EMC 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 Equipment Check portion (exposure curve) of the examination (i.e. if *not* certified at Level 1).
   - 16 hours (2 days) if you are *not* required to complete the General Equipment Check portion (exposure curve) of the examination (i.e. if certified 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 their own film. This decision will be made by the invigilator.

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. An 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 EMC Practical Examination Program

RT2 EMC Practical Examination Candidates shall complete the following:

1. General Equipment Check (only required if not level 1 certified)
    - Perform one (1) calibration test (Exposure curve)

2. EMC Practical Test
   Inspect 4 specimens and prepare 4 techniques:
    - one (1) heavy metal casting/forging and prepare a technique record;
    - one (1) light metal casting/forging and prepare a technique record;
    - two (2) welded specimens (one specimen will be inspected using gamma).

The technique for each 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 26 radiographs

4. 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 with 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 Radiographic Techniques:

The candidate will be provided with:

- the exam specimens;
- a specification which will dictate the requirements and limitations for all techniques
- the current isotope decay curve;
- film characteristic curves;
- logarithmic and anti-logarithmic tables;
- source size and effective x ray focal spot size;
- sketches of the exam specimens
- examination centre exposure curves.

Cautionary Note:

After the candidate has 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 specimens are to be considered critical all over and must be radiographed 100% with the required sensitivity and unsharpness as stated in the supplied specification. The radiography of welds includes the weld only and where feasible approximately one centimetre of the adjacent parent material.

The limits of the coverage for each radiograph must be indicated on the radiograph. This may be shown by lead numbers or arrows placed on the specimen or by marking the radiograph with film marking crayons.

When building a radiographic technique with identical cross sections of exam specimens that are required to be inspected by a series of identical radiographs and exposure parameters, then only the first exposure of that series needs be taken and submitted provided this series is properly indicated by the technique sheet.

The area on the radiograph where pertinent film density readings are taken by the candidate must be circled in order for examiner to verify the candidate's calculations.

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:

Where the candidate does not follow clearly stated guidelines (density, UG, sensitivity, etc.) the candidate's work is subject to rejection unless there are extenuating circumstances. These circumstances must be stated and supported by the invigilator.

There may be different ways to radiograph an exam specimen. Grading of a specimen will be according to the guidelines of coverage, radiograph density, sensitivity attained and economy of film and exposures.

Test exposures must be sent to the NDT Certification Body and must be separated from the final technique. A sample technique is provided for the candidates' information.

An invigilator may refuse to answer any question which is considered part of the test. Scribbled work is subject to rejection.

The candidate will use the film that is available at the centre. The candidate may be required to load and develop their own film. The film size should not exceed 8" X 10".

Each specimen 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.

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 an/OSL; wearing of a DRD; as well as maintaining safe exposure perimeter barriers when not working within the confines of a radiographic exposure room.

Specific Instructions for Gamma Exposure

The candidate:

- will be supplied with a charged dosimeter and the reading will be recorded after the completion of examination;
- will develop a radiographic technique for the exam specimen using the same procedure as for the x-ray technique;
- will be instructed in the safe operation of gamma camera;
- will be supplied with all safety devices and accessories for the gamma exposure;
- must follow safe working practices and ensure that individuals are never exposed to ionizing radiation beyond the permissible dose.

Demonstration 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 and neat. A sample of a completed technique reporting sheet is shown in Figure 1 as a guide to provide candidates with some assistance.

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

Figure 1 - Sample RT Level 2 Practical Examination Technique Reporting Sheet

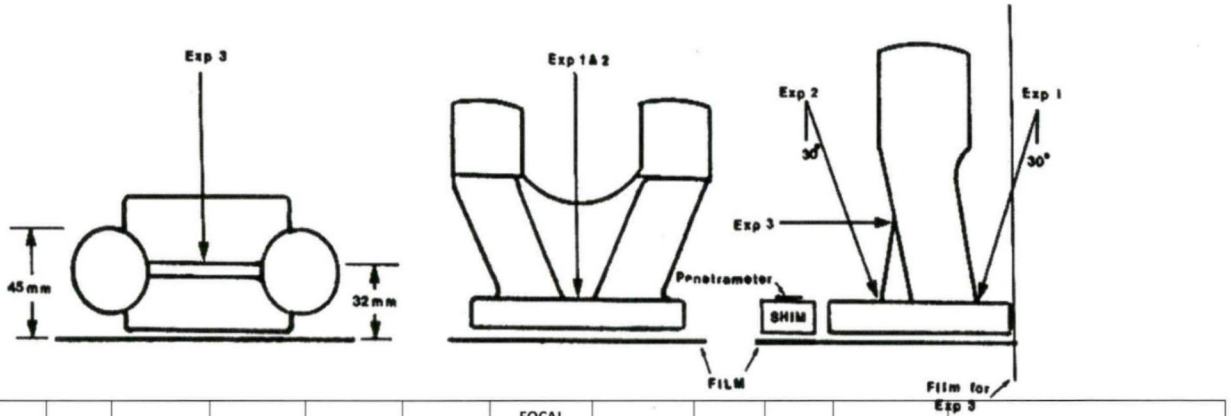
NAME: _____

DATE: _____

Source Size

	Length	Width	Diagonal
X-RAY	1.8mm	1.8mm	2.5 mm
GAMMA			

(mm)



EXPOSURE NUMBER	KV	MAS	THICKNESS	F.F.D.	FILM	SCREENS	FOCAL SPOT SIZE	U.G.	PEN.	ANGLE	EQUIPMENT	REMARKS
1	80	600	8mm	1 meter	Agfa D7	NIL	2.5 mm	.02	#6	30°	160 kV	
2	80	600	8mm	1 meter	Agfa D7	NIL	2.5 mm	.02	#6	30°	160 kV	Duplicate of Exp. 1
3	60	800	4mm 28mm	1 meter	Agfa D7	NIL	2.5 mm	.08 .118	#8 #22	90°	160 kV	

Suggestions for Success: RT2 EMC 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) welded specimen with Gamma radiation.
   - 2.5 hours to inspect one (1) welded specimen with X-radiation.
   - 2.5 hours to inspect one (1) light alloy specimen.
   - 2.5 hours to inspect one (1) heavy metal specimen.
   - 4 hours Interpret 26 radiographs.
   - 1 hour to write an NDT instruction for one of the examination specimens

4. Fill in all required information clearly and completely on the technique/reporting sheets provided. **Do not** use additional blank papers to write descriptions of techniques, there is sufficient space on the documents provided. If you require additional views to produce a more complete or comprehensive technique, you may draw the view you think is required; however, this may make the technique unclear and is not recommended. Scribbled work is subject to rejection.

5. There are many different ways to radiograph an exam specimen. Grading of the specimen will be according to the guidelines of coverage, density, and sensitivity attained. The technique must be written in a way that will enable a RT1 inspector to easily follow your steps and duplicate your results.

6. You may ask questions concerning the examination. The invigilator may refuse to answer any question if it is considered part of the examination requirements.

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

1. Candidates not adhering to density limits as described in the standard supplied by the exam centre.
2. Candidates incorrectly calculating unsharpness (UG) and developing techniques within the parameters of standard supplied by the exam centre.
3. Candidates not identifying areas of interest on exam specimens and inspecting for same.
4. Candidates not selecting proper penetrameters.
5. Candidates not producing a technique with sufficient information for a RT1 with limited experience to perform/achieve equal results.
6. Candidates incorrectly identifying the indications for the film interpretation portion.

Radiographic Testing Level 3

Radiographic Testing Level 3 (RT3) - Engineering, Materials and Components (EMC) 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	≥70%	• 30 multiple choice questions on the theoretical principles of RT	1 hour
EMC – Codes and Applications Written Examination	≥70%	• 40 multiple choice questions (total) ➢ 10 questions on codes (worth 4pts each) ➢ 30 questions on RT applications and techniques	2 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
EMC 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 they are 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 with higher education must successfully complete the Level 2 method-specific practical examination and the Radiation Protection written 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 EMC Practical Examination and the RT2 EMC Practical Examination Program.

Reference Material for RT3 EMC Written Examination Preparation

General and EMC Examinations

1. Classroom Training Handbook Radiographic Testing (CT-6-6) –General Dynamics
2. Radiography in Modern Industry – 4th Edition Eastman Kodak Company
3. Volume 17 Nondestructive Evaluation and Quality Control; by ASM International
4. Nondestructive Testing Handbook – Radiographic Testing – Latest Edition ASNT
5. Can/CGSB 48.5-95 (48-GP-5M)
6. Industrial Radiography by GE Inspection Technologies
7. Personnel Training Publications, Radiographic Testing; by ASNT
8. 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 Training Manual on Industrial Radiography
4. Canadian Nuclear Safety Commission Act and Regulations
5. Health Canada Safety Code 34

EMC - Codes and Applications Examination

The following five (5) codes/specifications/techniques were utilized as inspiration in drafting the RT3 EMC Sector Codes paper. New codes and questions are added periodically:

1. CSA Z184M
2. ASTM E-1025-84 Hole Type Image Quality Indicators Used for Radiography
3. Military Standard Inspection Radiographic MIL-STD-453C
4. MIL-1-6865 (ASG)
5. ASTM E-94 Standard Practice for Radiographic Testing

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 EMC 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.

Answers

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 EMC Codes and Applications Written Examination

1. Using geometric enlargement principles, determine the image size, if the object is 8 cm in diameter, the source-to-film distance is 1 meter and the object-film-distance is 3 cm.
    a) 86.95 mm
    b) 46.13 mm
    c) 89.88 mm
    d) 49.88 mm

2. A source of iridium192, whose half-life is 75 days, today provides an optimum exposure of a given test object in a period of 3.2 minutes. Five months from now, what exposure time would be required for the same radiographic density, under similar exposure conditions?
    a) 4.6 minutes
    b) 1.6 minutes
    c) 6.4 minutes
    d) 12.8 minutes

3. Cobalt-60 has a half-life of 5.4 years. After 3 years, what would be the strength of a source which was initially 1850 gigabecquerels?
    a) 3330 gigabecquerels
    b) 1036 gigabecquerels
    c) 1027 gigabecquerels
    d) 1258 gigabecquerels

4. The absorption of radiation by a material varies:
    a) directly with the square of the distance from the source.
    b) directly with the thickness of the material.
    c) inversely with the amount of scattering in the material.
    d) in an approximately exponential manner with the thickness of the material.

5. 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.

6. A wetting agent is added to an extra tank after final rinse in manual processing to:
    a) stabilize hardener
    b) eliminate dichroic stain
    c) eliminate brown stain
    d) eliminate water droplets

7. The radiographic appearance of diffraction patterns is mottled and may be confused with which one of the following sets of discontinuity indications?
    a) Porosity or segregation
    b) Oxidation or burn through
    c) Porosity or burst
    d) Misruns or porosity

8. When radiographing a specimen with a radiographic source, it is found that it is desirable to lengthen the source to film distance. With the source at the new location, the amount of radiation reaching the film will:
   a) vary inversely with the square of the distance.
   b) vary equally with the square of the distance.
   c) not change.
   d) vary inversely with the distance.

9. Tungsten is the preferred target material for x-ray tubes used in industrial x-ray tubes because it provides a double advantage. One of the advantages is its:
   a) efficiency in the production of x-rays is proportional to its atomic number.
   b) low melting point.
   c) efficiency in the production of x-rays is inversely proportional to its atomic number.
   d) high curie point.

10. The principal gamma ray energies emitted by iridium-192 are:
   a) 0.66, 0.84, 0.91 MeV
   b) 0.31, 0.47, 0.60 MeV
   c) 0.05, 0.05, 0.66 MeV
   d) 0.15, 1.12, 0.18 MeV

Answers

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

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 finishes of large castings are 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)							