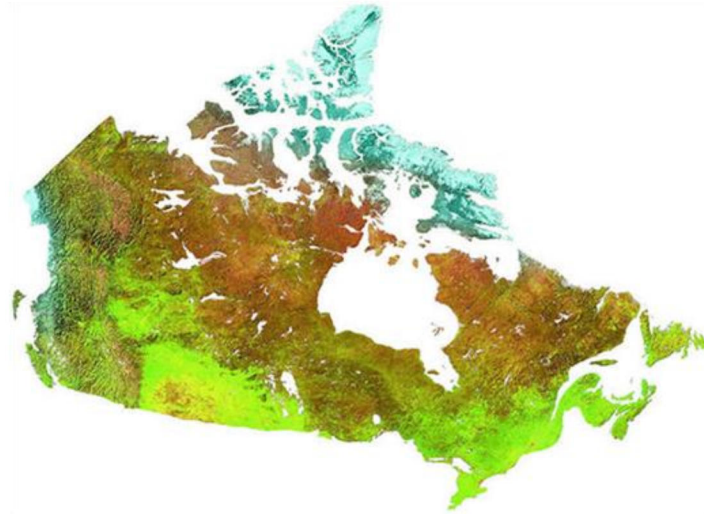




Ultrasonic Testing

Examination Guide for Initial Certification



Engineering, Materials and Components Sector

Canada



Contact Information

National Non-Destructive Testing Certification Body
CanmetMATERIALS
Natural Resources Canada
183 Longwood Road South
Hamilton, Ontario
L8P 0A5

Email: ndt-end@nrcan-rncan.gc.ca
Telephone: 1-866-858-0473
Web Site: <http://ndt.nrcan.gc.ca>

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
Hamilton, Ontario
L8P 0A5

Courriel : ndt-end@nrcan-rncan.gc.ca
Téléphone : 1-866-858-0473
Site Web: <http://end.nrcan.gc.ca>

Version 2 Description of Changes:

Revised online exam times and Written Instruction criteria



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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 (EWEA) form issued by NRCan NDTCB is required prior to purchasing an electronic written examination/re-examination. Failure to do this may either delay the start time of the certification examination or may not be allowed to take the 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 part (i.e. general, specific) and 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 part may be re-examined twice in the failed part(s), 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
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Ultrasonic Testing Level 1

Ultrasonic Testing Level 1 (UT1) - 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%	<ul style="list-style-type: none"> 40 multiple choice questions on the theoretical principles of UT. 	1 hour & 20 minutes
EMC (Specific) Written Examination	≥70%	<ul style="list-style-type: none"> 40 multiple choice questions (total) <ul style="list-style-type: none"> ➤ 15 questions on discontinuities, their names, locations and appearances, detectable by UT. ➤ 25 questions on UT applications and techniques. 	2 hours
Practical Examination	≥70% (on each specimen/subpart)	<ul style="list-style-type: none"> Performance/Calibration checks (General Practical) <ul style="list-style-type: none"> ➤ Eight (8) calibration exercises. ➤ One (1) performance check for determining beam spread. Two (2) specimen inspections, including inspection reports for each. <ul style="list-style-type: none"> ➤ One (1) weld specimen using the contact technique. ➤ One (1) formed product specimen using the contact technique. 	8 hours



Reference Material for UT1 EMC Written Examination Preparation

General and EMC Examinations

1. Non-destructive Testing Handbook - Ultrasonic Testing, by ASNT - Latest Edition
2. Ultrasonic Testing of Materials, J and H Krautkramer - Latest edition
3. ASM Metals Handbook – Volume 17; by ASM International
4. General Dynamics Classroom Training Handbook CT 4 by PH Diversified
5. Personnel Training Publications, Ultrasonic Testing; by ASNT
6. Handbook of Non-destructive Evaluation, 2nd edition; by Chuck Hellier
7. Ultrasonics: Fundamentals, Technologies, and Applications; by Dale Ensminger & Leonard J. Bond

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

Note: 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.



Sample Questions: UT1 General Written Examination

- Waves used in ultrasonic testing of materials are _____ in nature.
 - mechanical
 - magnetic
 - electromagnetic
 - harmonious
- The smallest distance between two points on an elastic wave where the particles are in the same state of motion is the:
 - period
 - wavelength
 - frequency
 - hypotenuse
- Particle motion in a longitudinal wave is:
 - parallel to the direction of wave propagation
 - at right angles to the direction of wave propagation
 - retrograde
 - in counterclockwise ellipses
- The fundamental frequency of a piezoelectric crystal used in ultrasonics is a function of:
 - its thickness
 - the velocity of sound in the crystal material
 - both a) and b)
 - none of the above
- A longitudinal wave generating transducer will have a given near field in steel. If in water the near field for this probe will be:
 - the same distance
 - about half as long
 - about 1/4 as long
 - about 4 times as long
- Bending of a sound wave upon entering a new medium is explained by:
 - Krautkramer's law
 - Snell's law
 - Boyle's law
 - Hooke's law
- Compared to water, the acoustic impedance of steel is:
 - higher
 - lower
 - about the same
 - higher or lower depending on the wave mode
- In ultrasonic testing a piezoelectric material is used to:
 - convert electric energy to mechanical energy
 - convert mechanical energy to electrical energy
 - both a) and b)
 - none of the above

Answer Key

1. a)	2. b)	3. a)	4. c)	5. d)	6. b)	7. a)	8. c)
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Sample Questions: UT1 EMC Written Examination

1. Cold shuts are _____ discontinuities.
 - a) inherent
 - b) processing
 - c) service
 - d) any of the above

2. A welding defect that occurs in the root pass and runs parallel with the weld is:
 - a) incomplete fusion between beads.
 - b) icicle.
 - c) crater crack.
 - d) incomplete joint penetration.

3. A burst is a discontinuity that may be found in:
 - a) a forging.
 - b) a rolled product.
 - c) an extrusion.
 - d) any of the above.

4. A stress corrosion crack is a defect of:
 - a) casting.
 - b) welding.
 - c) metal forming.
 - d) service.

5. Acoustic pressure along the beam axis moving away from the probe has various maxima and minima due to interference. At the end of the near field pressure is:
 - a) a maximum
 - b) a minimum
 - c) the average of all maxima and minima
 - d) none of the above

6. The main contribution to loss of sound pressure of a beam incident on a rough surface is provided by:
 - a) sound dispersion
 - b) mode conversion
 - c) refraction
 - d) diffraction

7. The ability to separate individual defects lying closely together is called:
 - a) sensitivity
 - b) resolution
 - c) angular acuity
 - d) linearity

8. In immersion testing you would normally position the:
 - a) entrance echo on the right edge of the CRT.
 - b) entrance echo on the left of the CRT.
 - c) first backwall on the right edge of the CRT.
 - d) none of the above



9. The preferred presentation method for determining the amplitude of an echo signal is the:
- a) A-scan.
 - b) B-scan.
 - c) C-scan.
 - d) D-scan.
10. The purpose of the IIW block is to determine:
- a) probe exit point
 - b) refracted angle
 - c) range (or depth scale)
 - d) all of the above

Answer Key:

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



General Information for the UT1 EMC Practical Examination

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

1. The duration of the UT1 practical examination is a maximum of 8 hours (1 day).
2. The UT1 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. Surface preparations are **not** permitted on the examination specimens. The candidate is requested to **not** mark the specimens, equipment and reference samples.
7. The candidate may ask questions concerning the examination. An invigilator may refuse to answer any questions they consider to be part of the examination requirements.
8. 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.



UT1 EMC Practical Examination Program

UT1 EMC Practical Examination Candidates shall complete the following:

1. Performance/Calibration Check

Perform the following calibration/performance tests according to instructions and record results/findings on the applicable reporting sheets:

- Perform eight (8) calibration exercises such as setting DAC, range, delay, sensitivity probe index, probe angle, etc.
- Complete the performance test for determining beam spread.

Note: Candidates must include all applicable units of measure when recording the results of the calibration/performance tests above.

2. Specimen Inspection

Inspect two (2) specimens according to written instructions and record results/findings on the applicable reporting sheets (**report measurements in millimetres**):

- One (1) weld specimen shall be inspected using the contact technique.
- One (1) formed product specimen shall be inspected using the contact technique.

Note: Draw the appearance of the indications on the illustration(s) provided in the reporting sheets as accurately as possible. Show the size, as well as the relative shape, length and location of the indications and ensure the inspection techniques are clearly shown. At minimum, use the illustration provided in the reporting sheets to draw the indications, but if necessary, draw a sketch of a missing view.

Suggestions for Success: UT1 EMC Practical Examination

1. Ensure that you have sufficient experience and knowledge in UT 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:
 - 30 minutes to read instructions and familiarize yourself with the requirements and the equipment.
 - 3 1/2 hours to conduct the calibration exercises/performance test.
 - 2 hours to inspect one (1) weld specimen and to complete the reporting sheets.
 - 2 hours to inspect one (1) formed product specimen and to complete the reporting sheets.
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. Do not hesitate to ask the invigilator questions. The invigilator will not answer a question if it is considered to be an examination requirement.



Ultrasonic Testing Level 2

Ultrasonic Testing Level 2 (UT2) - 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%	<ul style="list-style-type: none"> 40 multiple choice questions on the theoretical principles of UT. 	1 hour & 20 minutes
EMC (Specific) Written Examination	≥70%	<ul style="list-style-type: none"> 70 multiple choice questions (total) <ul style="list-style-type: none"> ➤ 30 questions on materials & processes and discontinuities. ➤ 10 questions on codes (worth 4pts each). ➤ 30 questions on UT applications and techniques. 	3 ½ hours
Practical Examination	≥70% (on each specimen/subpart)	<ul style="list-style-type: none"> Performance/Calibration checks (General Practical, only required if not successfully completed for level 1 certification) <ul style="list-style-type: none"> ➤ Eight (8) calibration exercises. ➤ One (1) performance check for determining beam spread. 	4 hours
		<ul style="list-style-type: none"> Four (4) specimen inspections, including inspection reports for each. <ul style="list-style-type: none"> ➤ Two (2) weld specimens using the contact technique. ➤ One (1) formed product specimen using the contact technique. ➤ One (1) formed product specimen using the immersion technique. <p>Detailed written instruction for one (1) of the inspected specimens.</p>	16 hours



Reference Material for UT2 EMC Written Examination Preparation

General and EMC Examinations

1. Non-destructive Testing Handbook - Ultrasonic Testing, By ASNT – Latest Edition
2. Ultrasonic Testing of Materials, J and H Krautkramer - Latest edition
3. ASM Metals Handbook – Volume 17; by ASM International
4. General Dynamics Classroom Training Handbook CT 4 by PH Diversified
5. Personnel Training Publications, Ultrasonic Testing; by ASNT
6. Handbook of Non-destructive Evaluation, 2nd edition; by Chuck Hellier
7. Ultrasonics: Fundamentals, Technologies, and Applications; by Dale Ensminger & Leonard J. Bond
8. W59-13 - Welded steel construction (metal arc welding)

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

Codes and Standards

The following five codes/specifications/techniques were utilized to draft the UT2 EMC examination questions on codes (new codes/questions may be added periodically):

1. Carbon steel axles, unheat-treated and heat-treated, for railway use (Inspired by A-21 Specification)
2. Ultrasonic examination of longitudinal welded pipe and tubing (Inspired by SE-273 Specification)
3. Ultrasonic examination of large, forged crankshafts (Inspired by A-503 Specification)
- Standard method for ultrasonic inspection of aluminum alloy plate for pressure vessels (Inspired by SB-548 Specification)
- Thickness measurement by manual contact ultrasonic method (Inspired by SE-797 Specification)

Note: 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.



Sample Questions: UT2 General Written Examination

1. The distance from a given point on an ultrasonic wave to the next corresponding point is referred to as:
 - a) frequency.
 - b) wavelength.
 - c) velocity.
 - d) pulse length.

2. In general, the result of two waves interacting on each other can be found by:
 - a) strobe lighting
 - b) vector addition
 - c) cross-multiplying
 - d) exponential summation

3. In resonance testing, indications may be obtained either at the fundamental resonant frequency or at _____ which are multiples of the fundamental frequency.
 - a) multiple reflections
 - b) harmonics
 - c) antinodes
 - d) nodes

4. A transducer has a near field in water of 35 mm. When used in contact on steel the near zone will be about:
 - a) 47 mm
 - b) 35 mm
 - c) 18 mm
 - d) 9 mm

5. The ratio of the reflected sound pressure to the incident sound pressure is called the:
 - a) acoustic impedance
 - b) acoustic intensity
 - c) coefficient of reflection
 - d) coefficient of transmission

6. Scatter of ultrasound is a result of:
 - a) frequency
 - b) sound velocity
 - c) angulation
 - d) some materials not being truly homogeneous

7. A PZT transducer will lose its piezoelectric property if:
 - a) immersed in water
 - b) used on a forging that has not been de-magnetized
 - c) used on a surface whose temperature is 140 degrees C
 - d) heated above its curie point

8. A rectangular probe, 4 mm X 8 mm, will have its maximum half angle of divergence:
 - a) in the 4 mm direction
 - b) in the 8 mm direction
 - c) in no particular orientation
 - d) constant in all directions



Answer Key

1. b)	2. b)	3. b)	4. d)	5. c)	6. d)	7. d)	8. a)
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Sample Questions: UT2 EMC Written Examination

- Which of the following factors can have a negative influence on some non-destructive tests?
 - Grain size.
 - Grain orientation.
 - Grain boundary composition.
 - All of the above.
- In which of the following welding processes is filler metal never added?
 - Brazing
 - Soldering
 - Arc welding
 - Spot welding
- A generally smooth indentation on a cast surface resulting from the meeting of two streams of metal coming from different directions and failing to fuse is called a:
 - stringer.
 - hot tear.
 - cold shut.
 - lap.
- Improper cleaning or insufficient preheating of a weldment, or moisture on the base metal or the filler metal could cause:
 - crater cracks.
 - porosity.
 - undercutting.
 - excessive penetration.
- Rayleigh waves can be used in steel to penetrate up to:
 - 10 mm.
 - 10 cm.
 - 1 m.
 - 1 wavelength.
- For best results detecting a defect that may be irregularly shaped and slightly off perpendicular to the beam, the wavelength used should be:
 - the size of the defect
 - as small as possible
 - as large as possible to locate the defect
 - 1 MHz
- A surface can be considered smooth if its irregularities are not more than _____ wavelength.
 - 1
 - 1/3
 - 1/10
 - 1/100



8. When testing a 30 mm diameter, 500 mm long shaft from the flat end of the shaft using longitudinal waves from a 20 mm diameter 2 MHz probe, numerous signals are seen on the screen after 500 mm. These are:
- a) ghost images
 - b) side wall echoes
 - c) internal thread indications
 - d) none of the above
9. In weld inspection, transverse cracks are best located by:
- a) scanning at right angles to the weld axis
 - b) scanning parallel to the weld axis
 - c) the lamination scan
 - d) immersion testing
10. For a shear wave travelling from steel to water incident on the boundary at 10 degrees will give a refracted shear wave in water with an angle of:
- a) 0 degrees
 - b) degrees
 - c) 20 degrees
 - d) none of the above

Answer Key:

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



General Information for the UT2 EMC Practical Examination

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

1. The duration of the UT2 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* Level 1 certified).
 - 16 hours (2 days) if you are *not* required to complete the General Practical portion of the examination (i.e. if Level 1 certified).
2. The UT2 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. Surface preparations are **not** permitted on the examination specimens. The candidate is requested to **not** mark the specimens, equipment and reference samples.
7. The candidate may ask questions concerning the examination. An invigilator may refuse to answer any questions they consider to be part of the examination requirements.
8. 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.



UT2 EMC Practical Examination Program

UT2 EMC Practical Examination Candidates shall complete the following:

1. Performance/Calibration Check(only required if not level 1 certified)

Perform the following calibration/performance tests according to instructions and record results/findings on the applicable reporting sheets:

- Perform eight (8) calibration exercises such as setting DAC, range, delay, sensitivity probe index, probe angle, etc.
- Complete the performance test for determining beam spread.

Note: Candidates must include all applicable units of measure when recording the results of the calibration/performance tests above.

2. Specimen Inspection

Inspect four (4) specimens according to written instructions and record results/findings on the applicable reporting sheets (**report measurements in millimetres**):

- Two (2) weld specimens shall be inspected using the contact technique.
- One (1) formed product specimen shall be inspected using the contact technique.
- One (1) formed product specimen shall be inspected using the immersion technique.

Note: Draw the appearance of the indications on the illustrations provided as accurately as possible and make a preliminary interpretation and evaluation of your findings. Show the size, as well as the relative shape, length and location of the indications and ensure the inspection techniques are clearly shown. When necessary, draw a sketch of a missing view.

3. Written Instruction

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

- a) Foreword – Scope of the inspection and reference documents.
- b) Personnel qualification requirements.
- c) List of equipment and accessories used.
- d) Description of the examination specimen, area of interest and purpose of the test.
- e) Description of test conditions and calibration procedures specific for the examination specimen.
- f) Detailed inspection procedures and settings specific for the examination specimen.
- g) Recording and classifying of test results.
- h) Reporting the results.

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



Suggestions for Success: UT2 EMC Practical Examination

1. Ensure that you have sufficient experience and knowledge in UT 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.
 - 4 hours to conduct the calibration exercises/performance test (if not level 1 certified).
 - 6 hours to inspect two (2) welded specimens using the contact technique and to complete the reporting sheets.
 - 3 hours to inspect one (1) formed product specimen using the contact technique and to complete the reporting sheets.
 - 3 hours to inspect one (1) formed product specimen using the immersion technique and to complete the reporting sheets.
 - 2 hours to write an NDT written instruction for one of the exam 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. Ensure that you correctly apply the concept of flaw sizing by the 6 dB drop technique.
7. Ensure that you write a complete **written instruction as indicated in the candidate instruction document**.
8. Do not hesitate to ask the invigilator questions. The invigilator will not answer a question if they consider it to be an examination requirement.



Ultrasonic Testing Level 3

Ultrasonic Testing Level 3 (UT3) - 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) <ul style="list-style-type: none"> • Part A: <ul style="list-style-type: none"> ➤ 70 questions on general Materials & Processes (M&P) and discontinuities specific to welds, castings, wrought products, etc. • Part B: <ul style="list-style-type: none"> ➤ 10 questions on CAN/CGSB 48.9712 standard • Part C: <ul style="list-style-type: none"> ➤ 60 questions (15 questions per method) on 4 NDT methods selected by candidate. 	4 hours
General Written Examination	≥70%	<ul style="list-style-type: none"> • 30 multiple choice questions on the theoretical principles of UT method. 	1 hour
EMC – Codes and Applications Written Examination	≥70%	<ul style="list-style-type: none"> • 40 multiple choice questions (total) <ul style="list-style-type: none"> ➤ 10 questions on codes (worth 5pts each) ➤ 30 questions on UT applications and techniques 	2 hours
Written Procedure ¹ or Written Procedure Review ²	≥70%	<ul style="list-style-type: none"> • 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)	<ul style="list-style-type: none"> • 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 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 UT2 EMC Practical Examination](#) and the [UT2 EMC Practical Examination Program](#).

Reference Material for UT3 EMC Written Examination Preparation

General and EMC Examinations

1. Non-destructive Testing Handbook - Ultrasonic Testing, By ASNT – Latest Edition
2. Ultrasonic Testing of Materials, J and H Krautkramer - Latest edition
3. ASM Metals Handbook – Volume 17; by ASM International
4. General Dynamics Classroom Training Handbook CT 4 by PH Diversified
5. Personnel Training Publications, Ultrasonic Testing; by ASNT
6. Handbook of Non-destructive Evaluation, 2nd edition; by Chuck Hellier
7. Ultrasonics: Fundamentals, Technologies, and Applications; by Dale Ensminger & Leonard J. Bond
8. W59-13 - Welded steel construction (metal arc welding)

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



EMC - Codes and Applications Examination

The following three (3) codes/specifications/techniques were utilized as inspiration in drafting the UT3 EMC Sector Codes paper. New codes and questions are added periodically:

1. Ultrasonic examination of welds, ASME
2. Military specification, Ultrasonic inspection immersion, of wrought metal, MIL-U-81055
3. Standard specification for longitudinal-beam ultrasonic inspection of carbon and low-alloy steel castings, ANSI/ASTM A609
4. Military specification, Ultrasonic inspection process, for wrought metals, MIL-I-8950B

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. 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 UT3 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: UT3 General Written Examination

1. The distance from a given point on an ultrasonic wave to the next corresponding point is referred to as:
 - a) frequency.
 - b) wavelength.
 - c) velocity.
 - d) pulse length.
2. Scatter of ultrasound is a result of:
 - a) frequency
 - b) sound velocity
 - c) angulation
 - d) some materials not being truly homogeneous
3. A PZT transducer will lose its piezoelectric property if:
 - a) immersed in water
 - b) used on a forging that has not been de-magnetized
 - c) used on a surface whose temperature is 140 degrees C
 - d) heated above its curie point
4. For a plane wave, sound pressure is reduced by attenuation in a _____ fashion.
 - a) linear
 - b) exponential
 - c) random
 - d) none of the above
5. At a solid to free boundary, an obliquely incident longitudinal wave from the solid can result in, at most:
 - a) a reflected longitudinal wave only
 - b) a reflected longitudinal and reflected shear wave
 - c) a refracted longitudinal long wave
 - d) a reflected longitudinal and reflected shear and refracted longitudinal wave
6. Geometrical optic treatment of ultrasonic waves fails to account for:
 - a) reflection
 - b) refraction
 - c) diffraction
 - d) normal incidence
7. Attenuation of an ultrasonic wave propagated through material can be attributed to:
 - a) absorption.
 - b) diffraction.
 - c) scattering.
 - d) all of the above.
8. Receiver noise must often be filtered out of a test system. Receiver amplifier noise increases proportionally to:
 - a) the square root of the amplifier bandwidth
 - b) the inverse square of the amplifier bandwidth
 - c) attenuation
 - d) temperature

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Answer Key:

1. b)	2. d)	3. d)	4. b)	5. b)	6. c)	7. d)	8. a)
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Sample Questions: UT3 EMC Codes and Applications Written Examination

1. Rayleigh waves can be used in steel to penetrate up to:
 - a) 10mm.
 - b) 10cm.
 - c) 1m.
 - d) 1 wavelength.

2. For best results detecting a defect that may be irregularly shaped and slightly off perpendicular to the beam, the wavelength used should be:
 - a) the size of the defect
 - b) as small as possible
 - c) as large as possible to locate the defect
 - d) 1 MHz

3. A surface can be considered smooth if its irregularities are not more than _____ wavelength.
 - a) 1
 - b) 1/3
 - c) 1/10
 - d) 1/100

4. When testing a 30 mm diameter, 500 mm long shaft from the flat end of the shaft using longitudinal waves from a 20 mm diameter 2 MHz probe, numerous signals are seen on the screen after 500 mm. These are:
 - a) ghost images
 - b) side wall echoes
 - c) internal thread indications
 - d) none of the above

5. In addition to a low critical temperature, lithium sulphate hydrate:
 - a) is soluble in water so must be water-proofed
 - b) is a poor impedance match to water
 - c) has the lowest coupling coefficient
 - d) none of the above

6. A large Q factor indicates:
 - a) high damping
 - b) narrow bandwidth
 - c) wide bandwidth
 - d) low permeability



7. Modern ultrasonics uses signal processing methods like signal averaging, spectral analysis, deconvolution auto-correlation and filtering to:
 - a) increase scanning speeds of automated systems
 - b) eliminate ultrasonic operators
 - c) provide smoother looking A-scans
 - d) obtain relevant information from raw ultrasonic data

8. To improve the accuracy of defect location and evaluation you should:
 - a) reduce gain
 - b) increase range
 - c) check calibration
 - d) use a probe of higher frequency

9. Flaws oriented obliquely to the incident sound beam may be better detected using:
 - a) high gain
 - b) higher frequency
 - c) probes
 - d) separate transmit and receive probes

10. If Z (water) is $1.5 \times 10^6 \text{ Ns/m}^3$ and Z (steel) is $45 \times 10^6 \text{ Ns/m}^3$, the pressure coefficient of reflection of a normally incident beam from steel is:
 - a) -1.236
 - b) -0.003
 - c) -0.935
 - d) -0.065

Answer Key:

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



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) overall 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:
- concentrated between the positive electrode and the work.
 - concentrated at the interface of the two plates to be welded.
 - concentrated between the negative electrode and the work.
 - evenly distributed in the work between the electrodes.
16. Which of the following is not a brazing process?
- Furnace brazing
 - Induction brazing
 - Infrared brazing
 - Electron beam brazing
17. Completely recrystallized hot rolled steel products have:
- exactly the same mechanical properties in the longitudinal and transverse directions.
 - superior mechanical properties in the direction of rolling.
 - superior mechanical properties in the transverse direction.
 - 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:
- inclusions.
 - seams.
 - cold shots.
 - bursts.
19. Bursts are caused by:
- casting at too low a temperature.
 - forging metal which is either too hot or too cold.
 - insufficient reduction in size is attempted in one forging operation.
 - none of the above.
20. Slag inclusions in welds are caused by:
- wide weaving.
 - incomplete de-slagging of a previous pass.
 - moisture entrapped in the joint.
 - 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?
- no change in exposure time is needed.
 - exposure time should be about 11% longer.
 - exposure time should be about 37% longer.
 - 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)							