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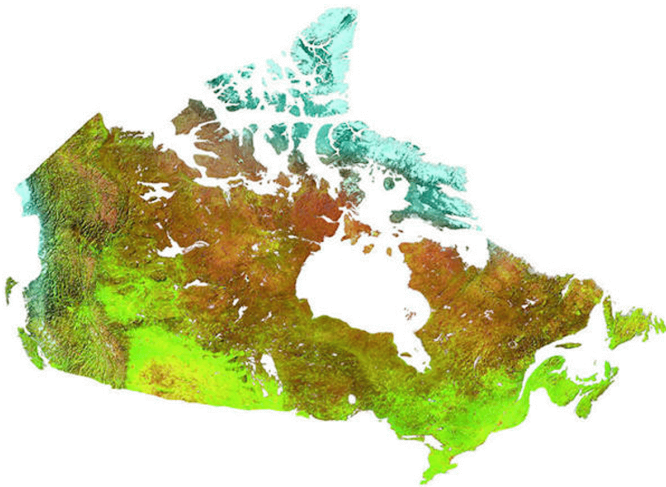
Minerals and
Metals Sector

Secteur des minéraux
et des métaux

Examination Guide for Initial Certification

Industrial Ultrasonics

Engineering, Materials and
Components Sector



Canada

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

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A INTRODUCTION

Natural Resources Canada (NRCan), through the Materials Technology Laboratory (MTL) of Minerals and Metals Sector (MMS), is the NDT Certifying Agency for the Canadian Nondestructive Testing Personnel Certification Program. NRCan certifies individuals according to CAN/CGSB 48.9712 standard.

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

- a) examines information provided by the applicant to ensure that the applicant has the basic education, NDT training and experience required by the standard;
- b) prepares, supervises and evaluates both written and practical examinations;
- c) maintains a network of test centres across Canada for both written and practical examinations;
- d) renews certificates of candidates as specified by the standard; and,
- e) recertifies candidates as specified by the standard.

In certifying the candidate, NRCan is only attesting that the candidate has demonstrated sufficient knowledge, skill, training and experience to meet the requirements of the CAN/CGSB 48.9712 standard. NRCan cannot attest to the operators competence in any specific situation at the time of original certification or at any time thereafter.

In undertaking the administration of the program, NRCan attempts to provide the unbiased Canada-wide services required to implement a national program. An Advisory Committee composed of individuals knowledgeable about NDT in Canada advises NRCan on the operation of this program.

IMPORTANT CANDIDATES USING THEIR OWN ULTRASONIC INSTRUMENTS

The candidates using their own instruments, while attempting the Ultrasonic practical examinations, shall meet the following two (2) requirements:

1. Candidates shall bring the "Operator's Manual" for the instrument, so the test centre supervisor can learn how to "clear" all data memories, at the beginning *and* end of *each* day of the practical examination; and
2. Instruments or systems capable of recording/storing data on strip-charts, disks and diskettes are not allowed during the practical examination.

If the candidates do not meet **both** of the above requirements, they will **not** be allowed to use their own instrument.

B.1 SUGGESTIONS FOR THE SUCCESSFUL COMPLETION OF WRITTEN EXAMINATIONS FOR CERTIFICATION IN NDT

1. Do some personal studying prior to attempting the written examinations. In general, training courses are meant to complement your personal efforts, not to substitute them. Furthermore, training courses tend to cover a lot of material over a short period of time. To assimilate the subject material covered, a great deal of personal studying is usually necessary.
Note: The marks obtained on a training course test should not be used to gauge your eventual performance on NRCan examinations. Usually, applicants find NRCan examinations more difficult.
2. Before starting a test, read all the instructions.
3. Before answering a multiple choice question read the stem and all of the options. Remember, only the best answer is correct.
4. If a question is difficult to answer, proceed by elimination. This will often result in having to choose between two possible options.
5. If you cannot answer a question, do not waste time, proceed to the next question. If you complete the test before the time limit, return to the unanswered questions.
6. To test your skills, we recommend the following sample questions that are available on the market:
 - a) Ginzler Bros. NDT Testmaker Questions Data Base
 - b) Supplements to Recommended Practice SNT-TC-1A (Question and Answer Books)

B.2 ULTRASONIC TESTING TRAINING REFERENCES

- A. Classroom Training Handbook: Ultrasonic Testing (CT-6-4), General Dynamics-Convair Division 1981
- B. ASM, Metals Handbook, 9th Edition, Volume 17, Nondestructive Evaluation and Quality Control, 1989
- C. Ultrasonic Testing of Materials, 3rd Edition, J and H Krautkramer, 1983
- D. ASNT, Nondestructive Testing Handbook, 2nd Edition, Volume 7, Ultrasonic Testing, 1991
- E. Ultrasonic Transducers for Nondestructive Testing, M.G. Silk, 1984
- F. Ultrasonics, 2nd Edition, Ensminger, 1988
- AA. ASNT, Materials and Processes for NDT Technology, 1981
- BB. BINDT, Basic Metallurgy for Non-Destructive Testing, 1989
- CC. CSA-W59-M1984, Welded Steel Construction
- DD. Programmed Instruction Handbook: Nondestructive Testing Handbook, Introduction (PI-4-1)
General Dynamics – Convair Division, 3rd Edition, 1967
- EE. Non-destructive testing – Qualification and certification of personnel CAN/CGSB 48.9712-2000

Reference Material

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

Canadian Institute for NDE
135 Fennell Avenue W., Port. #7
Hamilton, Ontario
L8N 3T2
Telephone: (905) 387-1640
Facsimile: (905) 574-6080

ASNT
1711 Arlingate Lane, Box 28518
Columbus, Ohio
43228 - 0518, U.S.A.
Telephone: (614) 274-6003 or 1-800-222-2768
Facsimile: (614) 274-6899

C.1 LEVEL 1 EXAMINATION SCHEME TO MEET THE CAN/CGSB - 48.9712 STANDARD

LEVEL 1 UT WRITTEN AND PRACTICAL EXAMINATIONS IN THE ENGINEERING MATERIALS AND COMPONENTS (EMC) SECTOR

<i>EXAMINATION</i>	<i>PASS</i>	<i>CONTENT</i>	<i>DURATION</i>	<i>COMMENTS</i>
General Paper	≥70%	40 m.c.q. on theoretical principles of UT method	1 hour	Need not be repeated for other sectors.
EMC Paper (Multi-Sector)	≥70%	40 m.c.q. total: -15 m.c.q. on flaws, their names, locations and appearances, detectable by UT; -25 m.c.q. on UT applications and simple techniques.	1 hour	
General Practical	≥70%	Make the required settings and operate the test equipment properly in order to obtain satisfactory results and correctly interpret results. Includes 8 calibrations such as setting DAC, range, delay, sensitivity, probe index, probe angle. Conduct 1 or 2 performance checks according to ASTM E-317 and/or determine beam profile.	½ day	All tests done according to written instructions.
EMC Practical (Multi-Sector)		Inspect 2 specimens, or parts thereof according to written instructions. Record results and test parameters.	½ day	Use test specimens with detailed instructions on how to inspect and record results.

m.c.q. ⇒ multiple choice questions

Note: For Level 1 certification, the composite grade (written and practical) must be ≥80%.

C.2 REFERENCES TO PREPARE FOR THE LEVEL 1 WRITTEN EXAMINATIONS

General and EMC Papers: References A, B and DD from page 3.

Important: From Chapter 7, in reference A, study **only** the subjects concerning the names, locations and general appearances of the casting, welding, metal forming, service and processing defects.

References are based on the Recommended Training Course Guidelines of Standard CAN/CGSB 48.9712 for Both General and EMC Papers

C.3 SAMPLE QUESTIONS FOR THE LEVEL 1 WRITTEN EXAMINATIONS

Level 1 General Examination:

1. Waves used in ultrasonic testing of materials are _____ in nature.
 - a) mechanical
 - b) magnetic
 - c) electromagnetic
 - d) harmonious

2. The smallest distance between two points on an elastic wave where the particles are in the same state of motion is the:
 - a) period
 - b) wavelength
 - c) frequency
 - d) hypotenuse

3. Particle motion in a longitudinal wave is:
 - a) parallel to the direction of wave propagation
 - b) at right angles to the direction of wave propagation
 - c) retrograde
 - d) in counterclockwise ellipses

4. The fundamental frequency of a piezoelectric crystal used in ultrasonics is a function of:
 - a) its thickness
 - b) the velocity of sound in the crystal material
 - c) both a and b
 - d) none of the above

5. A longitudinal wave generating transducer will have a given near field in steel. If in water the near field for this probe will be:
 - a) the same distance
 - b) about half as long
 - c) about 1/4 as long
 - d) about 4 times as long

6. Bending of a sound wave upon entering a new medium is explained by:
 - a) Krautkramer's law
 - b) Snells's law
 - c) Boyle's law
 - d) Hooke's law

7. Compared to water, the acoustic impedance of steel is:
 - a) higher
 - b) lower
 - c) about the same
 - d) higher or lower depending on the wave mode

8. In ultrasonic testing a piezoelectric material is used to:
 - a) convert electric energy to mechanical energy
 - b) convert mechanical energy to electrical energy
 - c) both a and b
 - d) none of the above

Answers

1. A 2. B 3. A 4. C 5. D 6. B
7. A 8. C

Level 1 E.M.C. 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

Answers

1. A 2. D 3. D 4. D 5. A 6. A 7. B
8. B 9. A 10. D

C.4 GENERAL INFORMATION FOR THE LEVEL 1 PRACTICAL EXAMINATIONS

1. The duration of the practical test is 1 day.
2. The level 1 ultrasonic practical examination is a closed book examination. No books or notes other than those provided will be permitted during the test. A scientific calculator may be used provided it does not contain information or established programs which provide solutions to examination problems.
3. The candidate shall be shown the operation and placement of equipment and accessories required to complete the test.
4. The candidate will be shown the accessible surfaces of the test specimens and reference samples.
5. No surface preparations are permitted on the test specimens, they must be used as is.
6. No permanent markings shall be placed on equipment, test pieces and reference samples.
7. The candidate is not allowed to take the paperwork nor the test specimens out of the laboratory. Thus, all reporting must be completed within the testing room or facility.
8. Candidates' questions will be answered unless the question is a test requirement. A supervisor may refuse to answer any question he considers to be part of the test.
9. Candidates will be given the opportunity to give feedback concerning the practical test. After completing the test, simply fill in and return the comment sheet provided. Hand in the comment sheet to the test supervisor or complete it at home and send directly to:
Jack Newbury
NDT Certifying Agency
568 Booth Street, Ottawa, Ontario K1A 0G1
Phone: (613) 996-4480 Fax: (613) 943-8297

Note: There is concern about candidates who appear confused and unsure of themselves while attempting their practical test. It is the prerogative of the supervisor to discuss this situation with the candidate and, in the extreme, terminate the practical test.

C.5 TEST PROGRAM FOR THE LEVEL 1 PRACTICAL EXAMINATIONS

The candidate is required to do the following:

General Practical Test:

1. Perform eight (8) calibration tests according to written instructions.
2. Perform two (2) performance tests according to written instructions.

EMC Practical Test:

1. Inspect a welded specimen according to written instructions.
2. Inspect a metal formed specimen according to written instructions.

C.6 HINTS FOR SUCCESSFUL LEVEL 1 PRACTICAL EXAMINATIONS

1. Do not spend too much time on one part of the test at the expense of the other parts. We suggest you devote:
 - 45 minutes to read the general information and familiarize yourself with the equipment and accessories.
 - 2.25 hours to perform eight (8) calibration tests.
 - 2.0 hours to perform two (2) performance tests.
 - 1.25 hours to inspect a welded specimen.
 - 1.25 hours to inspect a metal formed specimen.
2. Fill in the report sheets completely, clearly and neatly
3. Do not hesitate to ask questions to the supervisor. If the supervisor cannot answer your question because it is part of the test, he or she will tell you so.

D.1 LEVEL 2 EXAMINATION SCHEME TO MEET THE CAN/CGSB - 48.9712 STANDARD

***LEVEL 2 UT WRITTEN AND PRACTICAL EXAMINATIONS IN THE
 ENGINEERING MATERIALS AND COMPONENTS (EMC) SECTOR***

<i>EXAMINATION</i>	<i>PASS</i>	<i>CONTENT</i>	<i>DURATION</i>	<i>COMMENTS</i>
General Paper	≥70%	40 m.c.q. on theoretical principles of UT test method	1 hour	Need not be repeated for other sectors.
EMC Paper (Multi-Sector)	≥70%	70 m.c.q. total: - 30 m.c.q. on M&P and flaws - 10 m.c.q. (2 x 5) on codes - 30 m.c.q. on UT applications and techniques	2 ½ hours	
General Practical	≥70%	Performance/Calibration checks. Same as Level 1.	½ day	This exam need not be done again if successfully completed at Level 1.
EMC Practical (Multi-Sector)		Inspect 4 specimens: 2 welds, 1 forging and 1 extrusion. Prepare technique records and write one detailed instruction.	2 days	

m.c.q. ⇒ multiple choice questions

M&P ⇒ Materials and Processes

Note: For Level 2 certification, the composite grade (written and practical) must be ≥80%.

D.2 REFERENCES TO PREPARE FOR THE LEVEL 2 WRITTEN EXAMINATIONS

General and EMC Papers:

References A, B, C, E and F from page 3.

EMC Paper:

References AA, BB, CC and DD from page 3.

At the present, five (5) codes/specifications are used for Level 2 EMC paper. These are as follows:

1. Carbon steel axles, nonheat-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)
4. Standard method for ultrasonic inspection of aluminum alloy plate for pressure vessels (Inspired by SB-548 Specification)
5. Thickness measurement by manual contact ultrasonic method (Inspired by SE-797 Specification)

Note:

New codes and questions are added periodically.

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

References are based on the Recommended Training Course Guidelines of Standard CAN/CGSB 48.9712 for Both General and EMC Papers

D.3 SAMPLE QUESTIONS FOR THE LEVEL 2 WRITTEN EXAMINATIONS

Level 2 General 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

Answers

1. B 2. B 3. B 4. D 5. C
6. D 7. D 8. A

Level 2 E.M.C. Examination:

1. Which of the following factors can have a negative influence on some nondestructive tests?
 - a) Grain size.
 - b) Grain orientation.
 - c) Grain boundary composition.
 - d) All of the above.

2. In which of the following welding processes is filler metal never added?
 - a) Brazing
 - b) Soldering
 - c) Arc welding
 - d) Spot welding

3. 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:
 - a) stringer.
 - b) hot tear.
 - c) cold shut.
 - d) lap.

4. Improper cleaning or insufficient preheating of a weldment, or moisture on the base metal or the filler metal could cause:
 - a) crater cracks.
 - b) porosity.
 - c) undercutting.
 - d) excessive penetration.

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

6. 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

7. 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

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 echos
 - 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) 5 degrees
 - c) 20 degrees
 - d) none of the above

Answers

1. D 2. D 3. C 4. B 5. D 6. C 7. B
8. B 9. B 10. D

D.4 GENERAL INFORMATION FOR THE LEVEL 2 PRACTICAL EXAMINATIONS

1. The level 2 Ultrasonic practical examination is a closed book examination. No books or notes other than those provided will be permitted during the test. A scientific calculator may be used provided it does not contain information or established programs which provide solutions to examination problems.

The duration of the practical test is two and one half (2.5) days (19 hours). If the General Practical test has been completed at Level 1, the time required to complete the Level 2 practical test will be two (2) days (15 hours).

2. The candidate shall be shown the operation and placement of equipment and accessories required to complete the test.
3. The candidate will be shown the accessible surfaces of the test specimens and reference samples.
4. No surface preparations are permitted on the test specimens, they must be used as is.
5. No permanent markings shall be placed on equipment, tests pieces and reference samples.
6. The candidate is not allowed to take the paperwork nor the test specimens out of the laboratory. Thus, all reporting must be completed within the testing room or facility. At the end of each day all paperwork is given to the supervisor and will be returned to the candidate the following day. This process will be repeated until the time limit is reached.
7. Candidates' questions will be answered unless the question is a test requirement. A supervisor may refuse to answer any question he considers to be part of the test.
8. Candidates will be given the opportunity to give feedback concerning the practical test. After completing the test, simply fill in and return the comment sheet provided. Hand in the comment sheet to the test supervisor or complete it at home and send directly to:

Jack Newbury
NDT Certifying Agency
Natural Resources Canada
568 Booth Street
Ottawa, Ontario
K1A 0G1

Phone: (613) 996-4480
Fax: (613) 943-8297

Note: There is concern about candidates who appear confused and unsure of themselves while attempting their practical test. It is the prerogative of the supervisor to discuss this situation with the candidate and, in the extreme, terminate the practical test.

D.5 TEST PROGRAM FOR THE LEVEL 2 PRACTICAL EXAMINATIONS

The candidate is required to do the following:

General Practical Test {if not done at Level 1}

- A. Perform eight (8) calibration tests.
Perform two (2) performance tests.

EMC Practical Test

- B. Inspect 4 specimens:
one (1) extruded aluminum specimen by the immersion method.
one (1) metal formed specimen by the contact method.
two (2) welded specimens by the contact method.

C. NDT Written Instruction

Write a detailed instruction for one of the tested specimens. The written instruction must be completed in a manner that will permit a level 1 Ultrasonic inspector to follow your steps and duplicate your results. It should include:

- a. A description of the test specimen.
- b. A list of equipment, reference standards and accessories used.
- c. A description of the calibration procedures specific for the test specimen.
- d. A description of the inspection procedures specific for the test specimen.
- e. The instrument settings at the time of inspection.
- f. A report of the results.

Note: Although to write instructions a candidate may obtain inspiration from the general information accompanying the test specimen, he or she should remember that the NDT Certifying Agency requires a specific instruction to inspect a specific specimen.

D.6 HINTS FOR SUCCESSFUL LEVEL 2 PRACTICAL EXAMINATIONS

1. Budget your time. Don't spend too much time on one part of the test at the expense of the other parts. We suggest you devote:
 - 1 hour to read the general information and familiarize yourself with the equipment and accessories.
 - 2 hours to perform eight (8) calibration tests. (if not done at level 1)
 - 2 hours to perform two (2) performance tests. (if not done at level 1)
 - 5 hours to inspect two (2) welded specimens by the contact method.
 - 3 hours to inspect one (1) extruded aluminum specimen by the immersion method.
 - 3 hours to inspect one (1) metal formed specimen by the contact method.
 - 3 hours to write (1) NDT instruction for one of the above specimens.
2. Fill in the report sheets completely, clearly and neatly.
3. Do not hesitate to ask questions to the supervisor. If the supervisor cannot answer your question because it is part of the test, he or she will tell you so.

E.1 LEVEL 3 EXAMINATION SCHEME TO MEET THE CAN/CGSB - 48.9712 STANDARD

**LEVEL 3 UT WRITTEN AND PRACTICAL EXAMINATIONS IN THE
 ENGINEERING MATERIALS AND COMPONENTS (EMC) SECTOR**

<i>EXAMINATION</i>	<i>PASS</i>	<i>CONTENT</i>	<i>TIME</i>	<i>COMMENTS</i>
Basic Paper	≥70%	140 m.c.q. ¹ total: - 10 m.c.q. on CAN/CGSB 48.9712 standard - 30 m.c.q. on M&P ² (General) - 40 m.c.q. on M&P and flaws specific to welds, castings, wrought products, etc. - 60 m.c.q. (4 x 15) on NDT methods	3½ hours	Need not be repeated for other sectors and methods.
General Paper	≥70%	30 m.c.q. on theoretical principles of UT method	¾ hour	Need not be repeated for other sectors in UT.
Written Procedure ⁴ OR Written Procedure Review ⁵	≥70% ≥80% ³	Writing 1 NDT procedure for certification in the <i>first</i> method and the option of Reviewing an NDT procedure for certification in each <i>additional</i> method	4 hours OR 1 ½ hours	Need not be repeated for other sectors in UT.
EMC Sector –Codes and Applications Paper	≥70%	40 m.c.q. total: -10 m.c.q. on codes (2 x 5) -30 m.c.q. on UT applications	1 ¾ hours	
Practical Test	≥70%	Same as Level 2	2 ½ days	This exam need not be done again if successfully completed at Level 2.

¹ m.c.q. ⇒ multiple choice questions

² M&P ⇒ Materials and Processes

³ The General paper; EMC Sector Codes & Applications paper; and the Written Procedure/Review marks are weighted. A composite grade ≥80% is required.

⁴ Written Procedure Examination

This four hour examination **must** be completed by those seeking Level 3 certification in a **first method**. Because writing a comprehensive NDT procedure, which meets industrial standards, would normally take many days to complete, the NDT Certifying Agency will provide the applicant, at the time of application, with a pretest package having all the information and details needed to prepare for this examination.

⁵ Written Procedure Review Examination

Candidates seeking Level 3 certification in a **second and subsequent method** have the option of completing a one and one-half hour procedure review examination.

To complete this examination, the candidate will be handed a Procedure, in the applicable method, which he/she is to assume comes from their staff for review and approval. The candidate, as the responsible Level 3 individual for the company in question, must review the Procedure and identify all that is unsatisfactory or incorrect with the document. The candidate is required to write what is unsatisfactory or incorrect directly in the Procedure, adjacent to the problem area. An example of this will be shown in the Procedure to be reviewed.

The candidate must report *at least* 10 problem areas or deficiencies with the Procedure document. Deficiencies may include any of 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.

E.2 REFERENCES TO PREPARE FOR THE LEVEL 3 WRITTEN EXAMINATIONS

General and EMC-Codes and Applications Papers:

References A, B, C, D, E and F from page 3.

EMC-Codes and Applications Paper:

At the present, four (4) codes/specifications are used for Level 3 EMC codes and applications paper:

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

Note:

New codes and questions are added periodically.

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

Basic Paper:

References AA, BB, DD and EE from page 3.

Note:

A general familiarity with capabilities and limitations of other NDT methods is required for the Basic paper.

Written Procedure Examination

As indicated in E.1, notes 4 and 5, the NDT candidate will be provided with, at the time of application, a pretest package having all the information and details needed.

References are based on the Recommended Training Course Guidelines of Standard CAN/CGSB 48.9712 for the General and EMC Papers

E.3 SAMPLE QUESTIONS FOR THE LEVEL 3 WRITTEN EXAMINATIONS

Level 3 General 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. Geometric-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

Answers

1. B 2. D 3. D 4. B
5. B 6. C 7. D 8. A

Level 3 EMC-Codes & Applications Examination:

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

Answers

- | | | | | |
|------|------|------|------|-------|
| 1. D | 2. C | 3. B | 4. B | 5. A |
| 6. B | 7. D | 8. D | 9. D | 10. C |

Level 3 Basic Examination:

1. The Canadian standard for the certification of nondestructive testing personnel is developed and maintained by:
 - a) the Canadian General Standards Board (CGSB).
 - b) 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:
- to control the direction of crystallization.
 - to homogenize the structure and composition of the ingots.
 - to permit slow cooling of the ingots.
 - to bring them to the temperature required for rolling.
13. An advantage of using green sand molds over dry sand molds is:
- green sand molds are stronger than dry sand molds and thus are less susceptible to damage in handling.
 - surface finish of large castings are better when using green sand molds.
 - over-all dimensional accuracy of the mold is better with green sand.
 - 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:
- fully automated.
 - semi-automated.
 - carried out manually.
 - 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 deslagging 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:
- decrease the resolving power of the instrument.
 - increase the resolving power of the instrument.
 - have no effect on the test.
 - 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:
- circular method with magnetic field parallel to keyway.
 - circular method with magnetic field perpendicular to keyway.
 - using central conductor.
 - all of the above.
24. Which of the following physical properties, more than any other, determines what makes a material a good penetrant?
- viscosity.
 - surface tension.
 - wetting ability.
 - 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.
- steel
 - aluminum
 - copper
 - brass

Answers

- | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|
| 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 |

E.4 GENERAL INFORMATION FOR THE LEVEL 2 PRACTICAL EXAMINATIONS

1. The level 2 Ultrasonic practical examination is a closed book examination. No books or notes other than those provided will be permitted during the test. A scientific calculator may be used provided it does not contain information or established programs which provide solutions to examination problems.

The duration of the practical test is two and one half (2.5) days (19 hours). If the General Practical test has been completed at Level 1, the time required to complete the Level 2 practical test will be two (2) days (15 hours).

2. The candidate shall be shown the operation and placement of equipment and accessories required to complete the test.
3. The candidate will be shown the accessible surfaces of the test specimens and reference samples.
4. No surface preparations are permitted on the test specimens, they must be used as is.
5. No permanent markings shall be placed on equipment, tests pieces and reference samples.
6. The candidate is not allowed to take the paperwork nor the test specimens out of the laboratory. Thus, all reporting must be completed within the testing room or facility. At the end of each day all paperwork is given to the supervisor and will be returned to the candidate the following day. This process will be repeated until the time limit is reached.
7. Candidates' questions will be answered unless the question is a test requirement. A supervisor may refuse to answer any question he considers to be part of the test.
8. Candidates will be given the opportunity to give feedback concerning the practical test. After completing the test, simply fill in and return the comment sheet provided. Hand in the comment sheet to the test supervisor or complete it at home and send directly to:

Jack Newbury
NDT Certifying Agency
Natural Resources Canada
568 Booth Street
Ottawa, Ontario
K1A 0G1

Phone: (613) 996-4480
Fax: (613) 943-8297

Note: There is concern about candidates who appear confused and unsure of themselves while attempting their practical test. It is the prerogative of the supervisor to discuss this situation with the candidate and, in the extreme, terminate the practical test.

E.5 TEST PROGRAM FOR THE LEVEL 2 PRACTICAL EXAMINATIONS

The candidate is required to do the following:

General Practical Test {if not done at Level 1}

- A. Perform eight (8) calibration tests.
Perform two (2) performance tests.

EMC Practical Test

- B. Inspect 4 specimens:
one (1) extruded aluminum specimen by the immersion method.
one (1) metal formed specimen by the contact method.
two (2) welded specimens by the contact method.

C. NDT Written Instruction

Write a detailed instruction for one of the tested specimens. The written instruction must be completed in a manner that will permit a level 1 Ultrasonic inspector to follow your steps and duplicate your results. It should include:

- a. A description of the test specimen.
- b. A list of equipment, reference standards and accessories used.
- c. A description of the calibration procedures specific for the test specimen.
- d. A description of the inspection procedures specific for the test specimen.
- e. The instrument settings at the time of inspection.
- f. A report of the results.

Note: Although to write instructions a candidate may obtain inspiration from the general information accompanying the test specimen, he or she should remember that the NDT Certifying Agency requires a specific instruction to inspect a specific specimen.

E.6 HINTS FOR SUCCESSFUL LEVEL 2 PRACTICAL EXAMINATIONS

1. Budget your time. Don't spend too much time on one part of the test at the expense of the other parts. We suggest you devote:
 - 1 hour to read the general information and familiarize yourself with the equipment and accessories.
 - 2 hours to perform eight (8) calibration tests. (if not done at level 1)
 - 2 hours to perform two (2) performance tests. (if not done at level 1)
 - 5 hours to inspect two (2) welded specimens by the contact method.
 - 3 hours to inspect one (1) extruded aluminum specimen by the immersion method.
 - 3 hours to inspect one (1) metal formed specimen by the contact method.
 - 3 hours to write (1) NDT instruction for one of the above specimens.
2. Fill in the report sheets completely, clearly and neatly.
3. Do not hesitate to ask questions to the supervisor. If the supervisor cannot answer your question because it is part of the test, he or she will tell you so.