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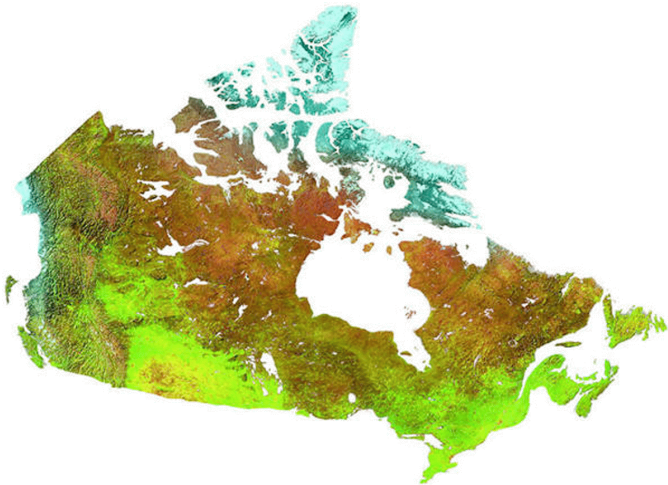
Minerals and
Metals Sector

Secteur des minéraux
et des métaux

Examination Guide for Initial Certification

Eddy Current

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 the 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 EDDY CURRENT INSTRUMENTS

The candidates using their own instruments, while attempting the Eddy Current 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) Ginzel Bros. NDT Testmaker Questions Data Base
 - b) Supplements to Recommended Practice SNT-TC-1A (Question and Answer Books)

B.2 EDDY CURRENT TESTING TRAINING REFERENCES

- A. Classroom Training Handbook: Eddy Current Testing (CT-6-5), General Dynamics-Convair Division, 1979
- B. ASNT, Fundamentals of Eddy Current Testing, Donald J. Hagemaiier, 1990
- C. CAN/CGSB-48.14-M86, Advanced Manual for Eddy Current Test Method, 1986
- D. ASNT, Nondestructive Testing Handbook, 2nd Edition, Volume 4, Electromagnetic Testing, 1986
- E. ASM, Metals Handbook, 9th Edition, Volume 17, Nondestructive Evaluation and Quality Control, 1989
- AA. ASNT, Materials and Processes for NDT Technology, 1981
- BB. BINDT, Basic Metallurgy for Non-Destructive Testing, 1989
- CC. Programmed Instruction Handbook: Nondestructive Testing Handbook, Introduction (PI-4-1)
General Dynamics – Convair Division, 3rd Edition, 1967
- DD. 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 EDDY CURRENT (ET) WRITTEN AND PRACTICAL EXAMINATIONS IN THE
ENGINEERING MATERIALS & 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 ET 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 ET; - 25 m.c.q. on ET 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 measuring resistivity of 2 samples, calibrating one absolute probe for plate inspection, and calibrating one absolute and one differential probe for tube inspection.	½ day	All tests done according to written instructions.
EMC Practical (Multi-Sector)		- Conduct thickness measurements of three non-conductive coatings - Size crack depths - Inspect one tube	½ day	All tests done according to written instructions.

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, C and CC 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. Choose the incorrect statement.
 - a) Eddy current testing was discovered by F.L. Eddie.
 - b) Faraday discovered electromagnetic induction.
 - c) Electromagnetic induction is the basis of the eddy current method.
 - d) Eddy current testing cannot be used to inspect non-conductors.
2. A symbol commonly used to express conductivity is:
 - a) μ .
 - b) σ .
 - c) X_L .
 - d) R.
3. A symbol commonly used to express permeability is:
 - a) μ .
 - b) σ .
 - c) X_L .
 - d) R.
4. A term used to define a material having a relative magnetic permeability larger than 1 is:
 - a) ferromagnetic.
 - b) conductor.
 - c) semiconductor.
 - d) insulator.
5. The symbol commonly used to signify inductance is:
 - a) Z.
 - b) X_L .
 - c) L.
 - d) I.

6. The alternating current required by the eddy current test is supplied by the:
 - a) transformer
 - b) phase rotator
 - c) AC to DC converter
 - d) sine wave oscillator
7. All materials have a characteristic resistance to the flow of electricity. Those having a low resistance are classified as:
 - a) insulators.
 - b) semiconductors.
 - c) conductors.
 - d) none of the above.
8. Pure annealed copper has a resistivity of $1.7241\mu\Omega\cdot\text{cm}$ at 20 degrees C. What must be done to this value to convert it to the 100% IACS value?
 - a) multiply by 0.01
 - b) divide by 100
 - c) divide by 0.017241
 - d) both a and b

Answers

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

Level 1 E.M.C. Examination:

1. Discontinuities most likely to be found in round bar stock are:
 - a) seams.
 - b) cold shuts.
 - c) grinding crack.
 - d) fatigue crack.
2. Which of the following is a service defect?
 - a) lack of penetration
 - b) undercut
 - c) fatigue crack
 - d) heat treatment crack
3. Eddy current method can be used to inspect:
 - a) conductors.
 - b) plastics.
 - c) ceramics.
 - d) concrete.
4. Eddy currents travel:
 - a) in closed paths.
 - b) in nonconductive materials.
 - c) axially when testing rod with an encircling coil.
 - d) perpendicular to the test surface.

5. At any given instant a spring loaded internal probe can inspect:
 - a) one complete circumference of the product.
 - b) an area roughly defined by the size of the probe coil.
 - c) one longitudinal line the length of the product.
 - d) none of the above.
6. Some products commonly tested with encircling probes are:
 - a) rods, tubes and wires.
 - b) interior of hollow tubes.
 - c) sheets and metallized foil.
 - d) all of the above.
7. Which of the following eddy current test coil arrangements compares one area of the test specimen, as a reference standard, to another area on the same specimen simultaneously?
 - a) Absolute coil
 - b) Gap coil
 - c) DC saturation coil
 - d) Differential coil
8. IACS is a recognized abbreviation for:
 - a) Induced Alternating Current System.
 - b) Inductively-Activated Comparison System.
 - c) Internal Applied Current System.
 - d) International Annealed Copper Standard.
9. In the IACS system of electrical conductivity measurement, pure copper is arbitrarily assigned the value of:
 - a) 0%.
 - b) 10%.
 - c) 50%.
 - d) 100%.
10. Which of the following test frequencies would produce eddy currents with the largest depth of penetration?
 - a) 100 Hz
 - b) 10 kHz
 - c) 1 MHz
 - d) 10 MHz

Answers

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

C.4 GENERAL INFORMATION FOR THE LEVEL 1 PRACTICAL EXAMINATIONS

1. The duration of the practical test is 1 day.
2. The level 1 eddy current 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. Although the reference specimens are not always ideal, the candidate shall manage with what is available.
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. Estimate the resistivity of two (2) unknown pieces.
2. Perform three (3) calibration tests:
 - Absolute mode for Plate Testing,
 - Absolute mode for Tube Testing,
 - Differential mode for Tube Testing.

EMC Practical Test:

1. Perform a non-conductive coating thickness measurement.
2. Perform a crack sizing.
3. Perform a tube inspection.

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.
 - 45 minutes to estimate the electrical resistivity of two (2) unknown pieces.
 - 2.0 hours to perform three (3) calibration tests.
 - 1.5 hours to perform a non conductive coating measurement.
 - 1.25 hours to perform a crack sizing.
 - 1.25 hours to perform a tube inspection.
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 EDDY CURRENT (ET) WRITTEN AND PRACTICAL EXAMINATIONS IN THE
ENGINEERING MATERIALS & 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 ET test method	1 hour	Need not be repeated for other sectors.
EMC Paper (Multi-Sector)	≥70%	60 m.c.q. total: -25 m.c.q. on M&P and flaws -10 m.c.q. (2 x 5) on codes -25 m.c.q. on ET applications and techniques	2 ¼ hours	
General Practical	≥70%	Resistivity/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 tubes and 2 aerospace samples (1 fastened assembly & 1 wheel section). Prepare technique records and write one detailed instruction.	1 ½ 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 and D from page 3.

EMC Paper: References AA, BB and CC from page 3.

At the present, three (3) codes/specifications are used for Level 2 EMC paper. These are as follows:

1. Eddy Current examination of seamless and welded tubular products, austenitic stainless steel and similar alloys (Inspired by SE-426 Specification)
2. Eddy Current testing of seamless copper and copper-alloy tubes (Inspired by SE-243 Specification)
3. Electromagnetic (Eddy Current) measurement of electrical conductivity (Inspired by E-1004 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. Which of the following statements is incorrect?
 - a) A constant amplitude magnetic field exists around a coil carrying a constant current (DC).
 - b) A periodically varying magnetic field exists around a coil carrying a periodically varying current.
 - c) When a coil carrying a constant current is brought near a conductor, constant currents (DC) are induced.
 - d) When a coil carrying a periodically varying current is brought near a conductor, periodically varying currents are induced.
2. When the voltage applied to a circuit and the current through the circuit both reach their maximums and minimums at the same time, the voltage and current are:
 - a) additive.
 - b) in phase.
 - c) regenerative.
 - d) out of phase.
3. Doubling the number of turns on a coil will:
 - a) double its inductance.
 - b) halve its inductance.
 - c) decrease its inductance by approximately a factor of four.
 - d) increase its inductance by approximately a factor of four.
4. What is a magnetically soft material?
 - a) A material capable of being magnetized permanently.
 - b) A material with a high coercive force.
 - c) A material with a low coercive force.
 - d) A material with low hardness value.

5. When a ferromagnetic metallic material is placed inside a test coil at low test frequencies, the flux density in the material is:
- less than the flux density generated by the test coil because of heat losses.
 - less than the flux density generated by the test coil because of resistivity.
 - the same as the flux density generated by the test coil in air.
 - greater than the flux density generated by the test coil in air.
6. To change radian units, often used in phase measurements in electric problems, to degrees you multiply by:
- 0.707
 - 1.414
 - 57
 - $\frac{t^2}{2}$
7. A surface crack in carbon steel plate during ET is sensed as a/an:
- increase in coupling.
 - decrease in coupling.
 - decrease in magnetic permeability.
 - increase in resistance to current flow.
8. Which is not a method used to gauge depth of a defect?
- pattern recognition
 - amplitude
 - phase angle
 - none of the above are depth gauging methods

Answers

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

Level 2 E.M.C. Examination:

1. In the following, the metal with the highest electrical conductivity is:
- copper
 - aluminum
 - silver
 - iron
2. As the temperature of metal increases, the electrical conductivity:
- increases
 - decreases
 - does not change
 - any of the above may occur depending on the type of metal.
3. The bores of fastener holes on aircraft are an important source of cracking caused by:
- fatigue.
 - burst.
 - overloading.
 - both a) and b).

4. A rupture in the material that can be in any direction on the part, and caused by localized stresses that exceed the tensile strength of the material is:
 - a) a fatigue crack.
 - b) a heat-treat crack.
 - c) a seam.
 - d) a stringer.
5. An eddy current probe can consist of:
 - a) a single test coil.
 - b) an excitation coil with a separate receive coil.
 - c) an excitation coil with a Hall-effect sensing detector.
 - d) all of the above.
6. Which of the following materials would have the highest resistivity value?
 - a) Aluminum with a 42% IACS rating
 - b) Magnesium with a 37% IACS rating
 - c) Cast steel with a 10.5% IACS rating
 - d) Zirconium with a 3.4% IACS rating
7. During measurement of conductivity of a specimen the effect of (error from) variations in test part thickness can be reduced by:
 - a) increasing test frequency.
 - b) decreasing test frequency.
 - c) decreasing fill-factor.
 - d) there is no practical method for reducing this effect.
8. A term used to define the phenomenon where, at very high frequencies, eddy current flow is restricted to an extremely thin outer layer of the conductor is:
 - a) skin depth effect.
 - b) high-frequency filtering.
 - c) low-frequency filtering.
 - d) any of the above.
9. To obtain the maximum signal (using a surface probe) from a defect of a given size at a given depth in a flat conductor there is:
 - a) an optimum size coil, but no optimum frequency.
 - b) an optimum frequency, but no optimum size coil.
 - c) an optimum frequency and optimum size probe.
 - d) no absolute optimum, but use the highest frequency and the smallest coil attainable.
10. Conductivity instruments can be used to sort materials with different:
 - a) electrical conductivity.
 - b) electrical resistivity.
 - c) magnetic permeability.
 - d) all of the above.

Answers

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

D.4 GENERAL INFORMATION FOR THE LEVEL 2 PRACTICAL EXAMINATIONS

1. The level 2 Eddy Current 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 (2) days (15 hours). If the General Practical test has been completed at Level 1, the time required to complete the Level 2 practical test will be one and one half (1.5) days (11 hours).
2. The candidate shall be shown the operation and placement of equipment and accessories required to complete the test.
3. Unless otherwise specified, it is the candidate's choice to use the proper probes for inspection of the test specimens.
4. The candidate will be shown the accessible surfaces of the test specimens and reference samples. Although the reference specimens are not always ideal, the candidate shall manage with what is available.
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, tests 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. 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.
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:

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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. Estimate the resistivity of two (2) unknown pieces.
Perform three (3) calibration tests:
- Absolute mode for plate testing,
 - Absolute mode for tube testing,
 - Differential mode for tube testing.

EMC Practical Test

- B. Inspect one (1) aircraft component for plate & fastener holes using surface and ring (encircling) probes.
Inspect one (1) aircraft wheel for bead seat using surface probe.
Inspect two (2) tubes for discontinuities using absolute and differential internal probes.

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 Eddy Current 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.
 - 1 hour to estimate the electrical resistivity of two (2) unknown pieces. (if not done at level 1)
 - 2 hours to perform three (3) calibration tests. (if not done at level 1)
 - 3.5 hours to inspect the plate and fastener holes of an aircraft component.
 - 1.5 hours to inspect the bead seat of an aircraft wheel.
 - 3.5 hours to inspect the two (2) tubes.
 - 2.5 hours to write one (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.

IMPORTANT NOTICE
Inspection of Riveted Panels

As you inspect the fastener holes, you will find some which are definitely flawed, others which are definitely sound. Identify, on the sketch provided, the flawed fastener holes.

There will be cases where the signal obtained from a fastener hole is so small that it will be difficult to interpret. Indicate such discrepancies on the sketch. Try to explain the source of the signal. The NDT Certifying Agency is looking for a "reasonable" explanation and not necessarily the "accurate" explanation.

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

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

EXAMINATION	PASS	CONTENT	TIME	COMMENTS
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 ET method	¾ hour	Need not be repeated for other sectors in ET.
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 ET.
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 ET 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 and D from page 3.

EMC-Codes and Applications Paper:

At the present, two (2) codes/specifications are used for Level 3 EMC codes and applications paper:

1. Electromagnetic (Eddy Current) sorting of ferrous metals
(Inspired by E-566 specification)
2. In situ electromagnetic (Eddy Current) examination of nonmagnetic heat exchanger tubes
(Inspired by E-690 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.

Basic Paper:

References AA, BB, CC and DD 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. When the voltage applied to a circuit and the current through the circuit both reach their maximums and minimums at the same time, the voltage and current are:
 - a) additive.
 - b) in phase.
 - c) regenerative.
 - d) out of phase.

2. When a ferromagnetic metallic material is placed inside a test coil at low test frequencies, the flux density in the material is:
 - a) less than the flux density generated by the test coil because of heat losses.
 - b) less than the flux density generated by the test coil because of resistivity.
 - c) the same as the flux density generated by the test coil in air.
 - d) greater than the flux density generated by the test coil in air.
3. To change radian units, often used in phase measurements in electric problems, to degrees you multiply by:
 - a) 0.707
 - b) 1.414
 - c) 57
 - d) $\frac{t^2}{2}$
4. Choose the correct statement.
 - a) for the best detection of cracks, eddy currents must flow parallel to the direction of the crack.
 - b) electric currents and their associated magnetic fields are perpendicular to each other.
 - c) nonmagnetic materials have a relative magnetic permeability greater than 10.
 - d) as the conductivity of a material increases, the eddy current depth of penetration increases.
 - e) when using conductivity standards for eddy current testing, the standard depth of penetration should exceed 4 times the thickness of the standard.
5. The quantity actually monitored by an eddy current probe is:
 - a) resistance
 - b) resistivity
 - c) probe electrical impedance
 - d) specimen thickness
6. A magnetic deposit is easy to detect because of its high:
 - a) electrical conductivity.
 - b) magnetic permeability.
 - c) electrical resistivity.
 - d) inductance.
 - e) none of the above.
7. If testing a material and you have set up acceptable conditions for phase separation of 90 degrees for 1 mm sample depth when relative magnetic permeability is 1, what depth would the 90 degrees separation occur at if relative magnetic permeability changed to 20?
 - a) 20 mm
 - b) 10 mm
 - c) 0.1 mm
 - d) 0.05 mm
8. Given a standard depth of penetration of 1.3 mm exists for a 10 kHz test on naval-brass ($6.63\mu\Omega\cdot\text{cm}$), what is the effective depth of penetration?
 - a) 1.3 mm
 - b) 3.9 mm
 - c) 5.2 mm
 - d) 6.5 mm

Answers

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

Level 3 EMC-Codes & Applications Examination:

1. An eddy current probe can consist of:
 - a) a single test coil.
 - b) an excitation coil with a separate receive coil.
 - c) an excitation coil with a Hall-effect sensing detector.
 - d) all of the above.
2. Which of the following materials would have the highest resistivity value?
 - a) Aluminum with a 42% IACS rating
 - b) Magnesium with a 37% IACS rating
 - c) Cast steel with a 10.5% IACS rating
 - d) Zirconium with a 3.4% IACS rating
3. During measurement of conductivity of a specimen the effect of (error from) variations in test part thickness can be reduced by:
 - a) increasing test frequency.
 - b) decreasing test frequency.
 - c) decreasing fill-factor.
 - d) there is no practical method for reducing this effect.
4. A term used to define the phenomenon where, at very high frequencies, eddy current flow is restricted to an extremely thin outer layer of the conductor is:
 - a) skin depth effect.
 - b) high-frequency filtering.
 - c) low-frequency filtering.
 - d) any of the above.
5. Choose the incorrect statement.
 - a) Eddy current testing is based on the process of inducing currents into a conductor and observing the interaction between the currents and the material.
 - b) The eddy currents are monitored by observing the effect of their associated electromagnetic field on the electrical impedance of the test coil.
 - c) In eddy current testing direct electrical contact with the sample is not required.
 - d) Eddy currents can be induced only in the first layer of a multilayer sample even at low test frequencies.
 - e) Eddy currents can be induced in ferromagnetic steels.
6. An eddy current probe with a 50 Ω impedance (at test frequency) has to be used on an eddy current instrument with a 100 Ω input impedance. Which of the following should be done:
 - a) add 50 Ω resistors in series with probe coils.
 - b) add 50 Ω inductors in parallel with probe coils.
 - c) add 50 Ω capacitors in parallel with probe coils.
 - d) use as is.
 - e) increase frequency by a factor of approximately two.

7. The decrease in eddy current density with depth into the sample is affected by:
 - a) test frequency.
 - b) surface probe coil diameter or internal probe coil length.
 - c) sample's resistivity and magnetic permeability.
 - d) presence of large defects.
 - e) all of the above.
8. At a fixed test frequency, in which of the following materials will the eddy current penetration be greatest?
 - a) Copper (100% IACS)
 - b) Aluminum (35% IACS)
 - c) Brass (15% IACS)
 - d) Bronze (12% IACS)
 - e) Iron (10% IACS)
9. Crack detectors normally:
 - a) are easier to use for defect detection because they have fewer controls than the general instruments.
 - b) cannot be used for inservice inspection because the test frequency cannot be changed to discriminate between defects and other indication like localized ferromagnetic variations.
 - c) can be used to detect large cracks in nonferromagnetic and ferromagnetic materials.
 - d) all of the above.
 - e) can be used only to detect tight fatigue cracks.
10. Which of the following parameters or material properties would normally give characteristically different signals?
 - a) Lift-off and wall thickness.
 - b) Cold work and impurities in a non-ferromagnetic material.
 - c) Hardness and electrical resistivity in a non-ferromagnetic material.
 - d) Lift-off and non-conducting layer on a conductor surface.
 - e) None of the above.

Answers

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

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:
 - a) to control the direction of crystallization.
 - b) to homogenize the structure and composition of the ingots.
 - c) to permit slow cooling of the ingots.
 - d) to bring them to the temperature required for rolling.
13. An advantage of using green sand molds over dry sand molds is:
 - a) green sand molds are stronger than dry sand molds and thus are less susceptible to damage in handling.
 - b) surface finish of large castings are better when using green sand molds.
 - c) over-all dimensional accuracy of the mold is better with green sand.
 - d) there is less danger of hot tearing of castings when using green sand molds.
14. Shielded metal-arc welding is a process of joining metals which is:
 - a) fully automated.
 - b) semi-automated.
 - c) carried out manually.
 - d) all of the above.
15. In the resistance spot welding of low-carbon steel the heat generated is:
 - a) concentrated between the positive electrode and the work.
 - b) concentrated at the interface of the two plates to be welded.
 - c) concentrated between the negative electrode and the work.
 - d) evenly distributed in the work between the electrodes.
16. Which of the following is not a brazing process?
 - a) Furnace brazing
 - b) Induction brazing
 - c) Infrared brazing
 - d) Electron beam brazing
17. Completely recrystallized hot rolled steel products have:
 - a) exactly the same mechanical properties in the longitudinal and transverse directions.
 - b) superior mechanical properties in the direction of rolling.
 - c) superior mechanical properties in the transverse direction.
 - d) inferior mechanical properties than the original cast structure.
18. Care must be taken not to splash steel on the walls of the mold when pouring to prevent formation of surface defects like:
 - a) inclusions.
 - b) seams.
 - c) cold shots.
 - d) bursts.

19. Bursts are caused by:
- 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 Eddy Current 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 (2) days (15 hours). If the General Practical test has been completed at Level 1, the time required to complete the Level 2 practical test will be one and one half (1.5) days (11 hours).
2. The candidate shall be shown the operation and placement of equipment and accessories required to complete the test.
3. Unless otherwise specified, it is the candidate's choice to use the proper probes for inspection of the test specimens.
4. The candidate will be shown the accessible surfaces of the test specimens and reference samples. Although the reference specimens are not always ideal, the candidate shall manage with what is available.
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, tests 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. 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.
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.

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. Estimate the resistivity of two (2) unknown pieces.
Perform three (3) calibration tests:
- Absolute mode for plate testing,
 - Absolute mode for tube testing,
 - Differential mode for tube testing.

EMC Practical Test

- B. Inspect one (1) aircraft component for plate & fastener holes using surface and ring (encircling) probes.
Inspect one (1) aircraft wheel for bead seat using surface probe.
Inspect two (2) tubes for discontinuities using absolute and differential internal probes.

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 Eddy Current 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.
 - 1 hour to estimate the electrical resistivity of two (2) unknown pieces. (if not done at level 1)
 - 2 hours to perform three (3) calibration tests. (if not done at level 1)
 - 3.5 hours to inspect the plate and fastener holes of an aircraft component.
 - 1.5 hours to inspect the bead seat of an aircraft wheel.
 - 3.5 hours to inspect the two (2) tubes.
 - 2.5 hours to write one (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.

IMPORTANT NOTICE
Inspection of Riveted Panels

As you inspect the fastener holes, you will find some which are definitely flawed, others which are definitely sound. Identify, on the sketch provided, the flawed fastener holes.

There will be cases where the signal obtained from a fastener hole is so small that it will be difficult to interpret. Indicate such discrepancies on the sketch. Try to explain the source of the signal. The NDT Certifying Agency is looking for a "reasonable" explanation and not necessarily the "accurate" explanation.