Eddy Current Testing

Examination Guide for Initial Certification

Engineering, Materials and Components Sector

Canada

Contact Information

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

Organisme de certification national en essais non destructifs
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Table of Contents

Overview of NRCan National Non-destructive Testing Certification Body Services

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

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

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

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

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

IMPORTANT NOTICE

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

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

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

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

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

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

Suggestions for Success: Written Examinations

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

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

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

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

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

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

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

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

Reference Material

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

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

Eddy Current Testing Level 1

Eddy Current Testing Level 1 (ET1) - Engineering, Materials and Components (EMC) Sector Examination Scheme in Accordance with CAN/CGSB-48.9712

Examination Part	Pass Grade	Examination Content	Duration
General Written Examination	≥70%	• 40 multiple choice questions on the theoretical principles of ET method.	1 hour & 20 minutes
EMC (Specific) Written Examination	≥70%	• 40 multiple choice questions (total) ➢ 15 questions on discontinuities, their names, locations and appearances, detectable by ET. ➢ 25 questions on ET applications and techniques.	2 hours
Practical Examination	≥70% (on each specimen/subpart)	• Performance/Calibration checks (General Practical) 1) Three (3) calibration exercises. 2) Two (2) resistivity checks • Three (3) specimen inspections including inspection data sheet for each. 1) Non-conductive coatings thickness measurements on three (3) specimens 2) Size Crack depths 3) Inspect one (1) tube	8 hours

Reference Material for ET1 EMC Written Examination Preparation

General and EMC Examinations

1. Classroom Training Handbook: Eddy Current Testing (CT-6-5), General Dynamics
2. ASNT, Fundamentals of Eddy Current Testing, Donald J. Hagemaier
3. CAN/CGSB-48.14-M86, Advanced Manual for Eddy Current Test Method
4. ASNT, Non-destructive Testing Handbook, Volume 4, Electromagnetic Testing
5. ASM, Metals Handbook, Volume 17, Non-destructive Evaluation and Quality Control
6. Personnel Training Publications, Eddy Current Testing; by ASNT
7. Handbook of Non-destructive Evaluation, 2nd edition; by Chuck Hellier

Materials and Processes

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

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

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

Sample Questions: ET1 General Written 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 1.7241μΩ·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

Sample Questions: ET1 EMC Written 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)

General Information for the ET1 EMC Practical Examination

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

1. The duration of the ET1 practical examination is a maximum of 8 hours (1 day).

2. The ET1 practical examination is a closed book examination. The use of any of the following is strictly **forbidden** and must be left outside the examination room.
   - Books, notes and papers belonging to the candidate.
   - Electronic devices (cell phones, tablets, cameras, etc.).
   - Other items which could provide answers/information for examination questions/content or are capable of recording examination material.

3. The candidate is **not** allowed to bring their own equipment and the candidate is **not** allowed to take the examination documents, equipment or specimens out of the laboratory/examination room. All reporting must be completed within the laboratory/ examination room.

4. The candidate will be supplied with the necessary examination equipment and accessories as per NRCan NDTCB examination centre requirements, as well as all reporting sheets, any additional examination documents, and additional paper supplies (provided by the examination centre) as needed to complete the examination.

5. The candidate will be shown the operation and placement of equipment and accessories required to complete the examination. Candidates are advised to review the candidate instructions included with the examination documents.

6. Surface preparations are **not** permitted on the examination specimens. The candidate is requested **not to** mark the specimens, equipment and reference samples.

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

8. The candidate has the opportunity to provide feedback concerning the practical examination. After completing the examination, the candidate will complete the comment sheet and place it into the return envelope with the examination paper(s) prior to sealing the envelope. The comment sheet will then be sent to the NRCan NDTCB along with the examination in the sealed return envelope.

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

ET1 EMC Practical Examination Program

ET1 EMC Practical Examination Candidates shall complete the following:

1. Performance/Calibration Check
   Perform the following calibration/performance tests according to instructions and record results/findings on the applicable reporting sheets:
   - Estimate the resistivity of two (2) pieces.
   - Perform three (3) calibration tests:
     a. Absolute mode for Plate Testing
     b. Absolute mode for Tube Testing
     c. Differential mode for Tube Testing

2. Specimen Inspection
   - Perform a non-conductive coating thickness measurement.
   - Perform a crack sizing.
   - Perform a tube inspection.

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

Suggestions for Success: ET1 EMC Practical Examination

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

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

3. Do not spend too much time on one part of the test at the expense of the other parts. We suggest you devote:
   - 30 minutes to read the general information and familiarize yourself with the equipment and accessories.
   - 1 hour to estimate the electrical resistivity of two (2) pieces.
   - 2 hours to perform three (3) calibration tests.
   - 1.5 hours to perform a non-conductive coating measurement.
   - 1.5 hours to perform a crack sizing.
   - 1.5 hours to perform a tube inspection.

4. Ensure that you **fully inspect** the specimen and report **all reportable indications**.

5. Fill in the reporting sheets clearly, completely and concisely, ensuring that you show the correct size, shape, length and location of the indications as **accurately** as possible on the illustrations provided in the reporting sheets (or if necessary, draw a sketch of a missing view).

6. Do not hesitate to ask the invigilator questions. The invigilator will not answer a question if it is considered to be an examination requirement.

Common Errors that may Result in Failure of the ET1 Practical Examinations

1. Candidates not reading the instructions which cost marks.
2. Candidates not having sufficient experience or knowledge of ET inspection.
3. Candidates having poor reporting skills: incorrect length, size, depth, and location of flaws. All reporting must be complete, clear, and concise.
4. Candidates having insufficient understanding of basic engineering drawings (top view, side view, end view). Therefore, incorrectly positioning each discontinuity accurately in two or more views.
5. Candidates not reporting all defects, not fully inspecting the specimen, stopping after finding 1 or 2 signals.

Eddy Current Testing Level 2

Eddy Current Testing Level 2 (ET2) - Engineering, Materials and Components (EMC) Sector Examination Scheme in Accordance with CAN/CGSB-48.9712

Examination Part	Pass Grade	Examination Content	Duration
General Written Examination	≥70%	• 40 multiple choice questions on the theoretical principles of ET method.	1 hour & 20 minutes
EMC (Specific) Written Examination	≥70%	• 70 multiple choice questions (total) ➢ 30 questions on materials & processes and discontinuities. ➢ 10 questions on codes (worth 4pts each). ➢ 30 questions on ET applications and techniques.	3 ½ hours
Practical Examination	≥70% (on each specimen/subpart)	• Performance/Calibration checks (General Practical, only required if not successfully completed for level 1 certification) ➢ Three (3) calibration exercises. ➢ Two (2) resistivity checks	4 hours
		• Four (4) specimen inspections, including inspection reports for each. ➢ Two (2) tube specimens ➢ Two (2) aerospace samples (1 fastened assembly & 1 wheel section) ➢ Detailed written instruction for one (1) of the inspected specimens.	12 hours

Reference Material for ET2 EMC Written Examination Preparation

General and EMC Examinations

1. Classroom Training Handbook: Eddy Current Testing (CT-6-5), General Dynamics
2. ASNT, Fundamentals of Eddy Current Testing, Donald J. Hagemaier
3. CAN/CGSB-48.14-M86, Advanced Manual for Eddy Current Test Method
4. ASNT, Non-destructive Testing Handbook, Volume 4, Electromagnetic Testing
5. ASM, Metals Handbook, Volume 17, Non-destructive Evaluation and Quality Control
6. Personnel Training Publications, Eddy Current Testing; by ASNT
7. Handbook of Non-destructive Evaluation, 2nd edition; by Chuck Hellier

Materials and processes

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

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

Codes and Standards

The following three (3) codes/specifications/techniques were utilized to draft the ET2 EMC examination questions on codes (new codes/questions may be added periodically):

1. Eddy Current examination of seamless and welded tubular products, austenitic stainless steel and similar alloys (Inspired by ASTM SE-426 Specification)
2. Eddy Current testing of seamless copper and copper-alloy tubes (Inspired by ASTM SE-243 Specification)
3. Electromagnetic (Eddy Current) measurement of electrical conductivity (Inspired by ASTM E-1004 Specification)

Note: Most of the subjects for examinations are found in the above publications. However it should be noted that additional studying from other books might be useful.

Sample Questions: ET2 General Written 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:
   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.

6. 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) $t^2/2$

7. A surface crack in carbon steel plate during ET is sensed as a/an:
   a) increase in coupling.
   b) decrease in coupling.
   c) decrease in magnetic permeability.
   d) increase in resistance to current flow.

8. Which is not a method used to gauge depth of a defect?
   a) pattern recognition
   b) amplitude
   c) phase angle
   d) 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

Sample Questions: ET2 EMC Written Examination

1. In the following, the metal with the highest electrical conductivity is:
   a) copper
   b) aluminum
   c) silver
   d) iron

2. As the temperature of metal increases, the electrical conductivity:
   a) increases
   b) decreases
   c) does not change
   d) 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:
   a) fatigue.
   b) burst.
   c) overloading.
   d) 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 receiver 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						

General Information for the ET2 EMC Practical Examination

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

1. The duration of the ET2 practical examination is a maximum of
   - 16 hours (2 days) if you are required to complete the General Practical portion (calibration exercises and performance test) of the examination (i.e. if *not* successfully completed at Level1).
   - 12 hours (1 ½ days) if you are *not* required to complete the General Practical portion of the examination (i.e. if successfully completed at Level 1).
2. The ET2 practical examination is a closed book examination. The following items are strictly **forbidden** and must be left outside the laboratory/examination room:
   - Books, notes and papers belonging to the candidate.
   - Electronic devices (cell phones, tablets, cameras, etc.).
   - Other items which could provide answers/information for examination questions/content or are capable of recording examination material.
3. The candidate is **not** allowed to bring their own equipment and the candidate is **not** allowed to take the examination documents, equipment or specimens out of the laboratory/examination room. All reporting must be completed within the laboratory/ examination room.
4. The candidate will be supplied with the necessary examination equipment and accessories as per NRCan NDTCB examination centre requirements, as well as all reporting sheets, any additional examination documents, and additional paper supplies (provided by the examination centre) as needed to complete the examination.
5. The candidate will be shown the operation and placement of equipment and accessories required to complete the examination. Candidates are advised to review the candidate instructions included with the examination documents.
6. Surface preparations are **not** permitted on the examination specimens. The candidate is requested **not to** mark the specimens, equipment and reference samples.
7. The candidate may ask questions concerning the examination. However, the invigilator may refuse to answer any question if it is considered part of the examination requirements.
8. The candidate has the opportunity to provide feedback concerning the practical examination. After completing the examination, the candidate will complete the comment sheet and place it into the return envelope with the examination paper(s) prior to sealing the envelope. The comment sheet will then be sent to the NRCan NDTCB along with the examination in the sealed return envelope.

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

ET2 EMC Practical Examination Program

ET2 EMC Practical Examination Candidates shall complete the following:

1. **Performance/Calibration Check** (only required if not successfully completed for level1 certification)
   Perform the following calibration/performance tests according to instructions and record results/findings on the applicable reporting sheets:
   - Estimate the resistivity of two (2) unknown pieces.
   - Perform three (3) calibration tests:
     a. Absolute mode for plate testing
     b. Absolute mode for tube testing
     c. Differential mode for tube testing

2. **Specimen Inspection**
   Inspect four (4) specimens according to written instructions and record results/findings on the applicable reporting sheets (report measurements in **millimeters**):
   - 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.

3. **Written Instruction**
   Complete a detailed written instruction for one of the specimens. The instruction must be written in a way that will enable another ET inspector to easily follow the steps and duplicate the results. It should include:
   a. Foreword – Scope of the inspection (method used and limitations of the method), reference documents;
   b. Personnel qualification requirements;
   c. List of equipment, reference standards and accessories used.;
   d. Product - Description or drawing of the examination specimen, including area of interest and purpose of the test;
   e. Test conditions, including preparation for testing and equipment calibration procedures;
   f. Detailed instructions for application of the test, including settings;
   g. Recording and classifying of test results;
   h. Reporting the results.

Note: A candidate may use the general information accompanying the exam specimen for writing the instruction; however, the candidate must keep in mind that the NDTCB requires a specific instruction to inspect a specific specimen.

Suggestions for Success: ET2 EMC Practical Examination

1. Ensure that you have sufficient experience and knowledge in ET inspection prior to booking your practical examination.
2. When you begin your practical examination, ensure that you **carefully read the examination instructions** prior to proceeding with the examination requirements.
3. Do not spend too much time on one section of the examination at the expense of the other sections. We suggest that you devote:

- 1 hour to read 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.
- 2 hours to inspect the bead seat of an aircraft wheel.
- 4 hours to inspect the two (2) tubes.
- 2.5 hours to write one (1) NDT instruction for one of the above specimens.

4. Ensure that you **fully inspect** the specimen and report **all reportable indications**.
5. Fill in the reporting sheets clearly, completely and concisely, ensuring that you show the correct size, shape, length and location of the indications, as **accurately** as possible on the illustrations provided in the reporting sheets (or if necessary, draw a sketch of a missing view).
6. Ensure that you write a complete **written instruction as indicated in the candidate instruction document**.
7. Do not hesitate to ask the invigilator questions. The invigilator will not answer a question if they consider it to be an examination requirement.

Common Errors that may Result in Failure of the ET2 Practical Examinations

1. Candidates not reading the instructions which cost marks.
2. Candidates not having sufficient experience or knowledge of Eddy Current inspection. This is the root cause of most examination failures:
   a. inability to calculate the correct frequency
   b. unable to choose the right diameter of probe
   c. unable to analyze the signal of the tube inspection
3. Candidates having poor reporting skills and not plotting flaws correctly: incorrect length, size, depth, and location of flaws. All reporting must be complete, clear, and concise.
4. Candidates not locating the centre and area of the eddy current field on the probe; thus unable to locate and size defects (e.g. plotting flaws with the tube turned around backwards).
5. Candidates having insufficient understanding of basic engineering drawings (top view, side view, end view). Therefore, incorrectly positioning each discontinuity accurately in two or more views.
6. Candidates not reporting all defects, not fully inspecting the specimen, stopping after finding 1 or 2 signals.
7. Candidates not staying in the area described in the scan instructions for wheel Inspection as flaws may be small.
8. Candidates failing to find the flaws because of poor calibration. To be successful, candidates need to choose an appropriately sized probe (e.g. a small point ‘pencil’ probe).

Important Note on Inspection of Riveted Panels

In inspecting fastener holes, there will be some fastener holes that are sound and others that are flawed. Identify the flawed fastener holes on the sketch provided.

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 Certification Body is looking for a "reasonable" explanation and not necessarily an "accurate" explanation.

Eddy Current Testing Level 3

Eddy Current Testing Level 3 (ET3) - Engineering, Materials and Components (EMC) Sector Examination Scheme in Accordance with CAN/CGSB-48.9712

Examination Part	Pass Grade	Content	Duration
Basic Written Examination: Parts A, B and C (Unless successfully completed during other Level 3 method certification)	≥70% (on each part)	140 multiple choice questions (total) • Part A: ➢ 70 questions on general Materials & Processes (M&P) and discontinuities specific to welds, castings, wrought products, etc. • Part B: ➢ 10 questions on CAN/CGSB48.9712 standard • Part C: ➢ 60 questions (15 questions per method) on 4 NDT methods selected by candidate.	4 hours
General Written Examination	≥70%	• 30 multiple choice questions on the theoretical principles of ET method.	1 hour
EMC – Codes and Applications Written Examination	≥70%	• 40 multiple choice questions (total) ➢ 10 questions on codes (worth 5pts each) ➢ 30 questions on ET applications and techniques	2 hours
Written Procedure[1] **or** Written Procedure Review[2]	≥70%	• Write one NDT procedure (required for first Level 3 certification). • Option to instead review an NDT procedure (for each additional Level 3 method certification)	4 hours **or** 1½ hours
EMC Practical Examination (If not successfully completed at Level 2)[3]	≥70% (on each specimen/subpart)	• Same as level 2 examination	16 **or** 20 hours

[1] **Written Procedure:**

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

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

[2] **Written Procedure Review:**

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

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

[3] **Practical Examination:**

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

- A candidate who is Level 2 in the same NDT method and product sector or who has successfully passed a Level 2 practical examination for the same NDT method and product sector is exempt from the Level 2 practical examination.
- Please refer to the General Information for the ET2 EMC Practical Examination and the ET2 EMC Practical Examination Program.

Reference Material for ET3 EMC Written Examination Preparation

General and EMC Examinations

1 Classroom Training Handbook: Eddy Current Testing (CT-6-5), General Dynamics
2 ASNT, Fundamentals of Eddy Current Testing, Donald J. Hagemaier
3 CAN/CGSB-48.14-M86, Advanced Manual for Eddy Current Test Method
4 ASNT, Non-destructive Testing Handbook, Volume 4, Electromagnetic Testing
5 ASM, Metals Handbook, Volume 17, Non-destructive Evaluation and Quality Control
6 Personnel Training Publications, Eddy Current Testing; by ASNT
7 Handbook of Non-destructive Evaluation, 2nd edition; by Chuck Hellier
8 Programmed Instruction Handbook: Non-destructive Testing Handbook, Introduction (PI-4-1) General Dynamics
9 ASNT, Materials and Processes for NDT Technology
10 BINDT, Basic Metallurgy for Non-Destructive Testing
11 Non-destructive testing - Qualification and certification of personnel CAN/CGSB 48.9712

Materials and Processes

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

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

EMC - Codes and Applications Examination

The following two (2) codes/specifications/techniques were utilized as inspiration in drafting the ET3 EMC Sector Codes paper. New codes and questions may be added periodically:

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

Basic Examination (Parts A, B & C)

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

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

Written Procedure Examination

As indicated in the ET3 EMC examination scheme (above), the candidate will be provided with (at the time of application) a pre-examination package that includes all the information and details necessary to prepare for the examination.

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

Sample Questions: ET3 General Written 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) $t^2/2$

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) As the conductivity of a material increases, the eddy current depth of penetration increases.
   d) 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.

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) 0.22 mm

8. Given a standard depth of penetration of 1.3 mm exists for a 10 kHz test on naval brass (6.63μΩHcm), 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

Sample Questions: ET3 EMC Codes and Applications Written Examination

1. An eddy current probe can consist of:
   a) a single test coil.
   b) an excitation coil with a separate receiver 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.

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.

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) 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)

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 in-service 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 non-ferromagnetic and ferromagnetic materials.
   d) all of the above.

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.

Answers:

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

Sample Questions: Level 3 Basic Written Examination

1. The Canadian standard for the certification of non-destructive testing personnel is developed and maintained by:
   a) the Canadian General Standards Board (CGSB).
   b) 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 buildup.
   b) some metals, such as stainless steel, have a high conductivity which results in lack of fusion defects as the heat is quickly removed from the weld zone.
   c) in some metals, such as aluminum, very high temperature gradients are produced, causing stresses during cooling.
   d) none of the above.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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							