GUIDE TO QUALIFICATION AND CERTIFICATION OF NON-DESTRUCTIVE TESTING PERSONNEL IN SRI LANKA

NATIONAL CERTIFICATION BODY FOR NON-DESTRUCTIVE TESTING
SRI LANKA

NCBNDT

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1 GENERAL INFORMATION

1.1. Introduction

The qualification and certification of Non-Destructive Testing (NDT) personnel in Sri Lanka is carried out in accordance with the international standards of ISO/IEC 17024 and ISO/IEC 9712 with the latest editions by the National Certification Body for Non-Destructive Testing Personnel (NCBNDT) of Sri Lanka Atomic Energy Board (SLAEB).

This manual is provided information on basic requirements, eligibility, candidate evaluation, and maintenance of validity of qualification and certification in accordance with the ISO 9712 and ISO 17024 for NDT personnel and other NDT related parties.

1.2. The NCBNDT

The NCBNDT-Sri Lanka is a separate entity under the purview of SLAEB and facilitated by the National Centre for Non-Destructive Testing (NCNDT) of SLAEB for its smooth functioning. The Council of NCBNDT is the Board of SLAEB, and it has delegated the responsibility for maintaining a management overview of the operations of its qualification and certification services to a Technical Advisory Committee (TAC). The NCBNDT-Sri Lanka consists of two main sections, i.e. Examination Committee (EC) for qualification services and the Certification Unit (CU) for certification services.

1.2.1 The NCBNDT Comprises:

- The Chairman (Chairman - SLAEB)
- The Council Members (Council Members - SLAEB)
- TAC Chairman (Director General - SLAEB)
- TAC Members;
    - External- appointed by the Chairman-SLAEB from industries
    - Internal - Director-NCNDT and Deputy Director-NCNDT
- The Secretary of TAC
- Deputy Quality Manager-NCBNDT
- Examination Committee;
    - Chairman
    - Deputy Chairman
    - Assistant Deputy Chairman
    - Technical Assistant
    - Management Assistant
- A Panel of Examiners and Invigilators
- Certification Unit;
    - Officer in Charge
    - Second Officers
    - Management Assistant / Office Aid

The Council of NCBNDT is responsible for the decision on the certification status of an applicant based on the recommendations given by the TAC of NCBNDT. Maintaining, renewal, re-certification of the certification, and suspending or withdrawing the certification are under the sole authority of the Council of NCBNDT.

1.2.2 National Recognition

The NCBNDT has been accredited by the Sri Lanka Accreditation Board for Conformity Assessment (SLAB) in accordance with ISO 17024.

SLAB Logo

1.2.3 International Recognition

The NCBNDT has achieved international recognition by registering as a Personnel Certification Body (PCB) under the International Committee for Non-Destructive Testing (ICNDT) Multilateral Recognition Agreement (MRA) Schedule 2 for Personnel Certification in NDT.

ICNDT Logo

2 SCOPE

This document describes the NCBNDT process for the qualification and certification of NDT personnel and all required information at each level in the NDT methods and industry or product sectors.

3 REFERENCES

- ISO/IEC17024: General requirements for bodies operating certification systems of persons
- IAEA TECDOC – 628/Rev.03, “Training Guidelines in Non-Destructive Testing Techniques”.
- ISO/TR 25108: Non-destructive testing – Guidelines for NDT personnel training organization (ISO/TR 25108)
- ISO 9712:Non-destructive testing - Qualification and certification of personnel
- AINDT: Guide to qualification and certification non-destructive testing

Note: All References to standards in this document relate to the latest edition of that standard.

4 TERMS AND DEFINITIONS

The following terms and definitions are applied within this document.

4.1 Basic examination

A written examination at Level 3 that demonstrates the candidate's knowledge of materials science and process technology, types of discontinuities, the specific qualification and certification system, and the basic principles of NDT methods as required for Level 2.

4.2 Candidate

An individual seeking qualification and certification who gains experience under the supervision of personnel having a qualification acceptable to the certification body**.**

4.3 Certificate

Document issued by the certification body under specified provisions, indicating that the named person has demonstrated the competence(s) defined on the certificate and has met all the requirements for certification.

4.4 Certification

A procedure used by the certification body to confirm that the qualification requirements for a method, level, and sector have been fulfilled, leading to the issuing of a certificate.

4.5 Certification Body

A body that administers procedures for certification according to specified requirements

4.6 Employer

Organization for which the candidate works on a regular basis.

4.7 Examiner

A person certified to Level 3 in the method they are authorized by the certification body to conduct, supervise, and grade the qualification examination.

4.8 Examination centre

Centre approved by the certification body where qualification examinations are carried out.

4.9 General examination

A written examination at Level 1 or Level 2, concerned with the principles of an NDT method.

4.10 Industrial experience

Experience, acceptable to the certification body, gained under qualified supervision in the application of the NDT method in the sector concerned, needed to acquire the skill and knowledge to fulfil the provisions of qualification

4.11 Invigilator

A person authorized by the certification body to supervise examinations.

4.12 Main-method examination

Written examination at Level 3, which demonstrates the candidate's general and specific knowledge, and the ability to write NDT procedures for the NDT method as applied in the industrial or product sector(s) for which certification is sought**.**

4.13 Multiple choice examination question

The wording of a question gives rise to four potential replies, only one of which is correct, the remaining three being incorrect or incomplete.

4.14 NDT instruction

The written description of the precise steps to be followed in testing to an established standard, code, and specification, or NDT procedure.

4.15 NDT method

Discipline applying a physical principle in Non-destructive Testing

- Ex- Ultrasonic testing.

4.16 NDT procedure

A written description of all essential parameters and precautions to be applied when non-destructive testing products in accordance with standard(s), code(s), or specification(s).

4.17 NDT technique

A specific way of utilizing an NDT method

- Ex- Immersion ultrasonic testing

4.18 NDT training

Process of instruction in theory and practice in the NDT method in which certification is sought, which takes the form of training courses to a syllabus approved by the certification body.

4.19 Practical examination

Assessment of practical skills with which the candidate demonstrates familiarity and the ability to perform the test.

4.20 Qualification

Demonstration of physical attributes, knowledge, skill, training, and experience required to perform NDT tasks properly.

4.21 Qualified supervision

Supervision of candidates gaining experience by NDT personnel certified in the same method under supervision or by non-certified personnel who, in the opinion of the certification body, possess the knowledge, skill, training, and experience required to perform such supervision properly.

4.22 Qualification examination

Examination administered by the certification body or the authorized qualification body, which assesses the general, specific, and practical knowledge and skills of the candidate.

4.23 Renewal

The procedure for revalidation of a certificate without examination at any time up to five years after success in an initial or re-certification examination**.**

4.24 Re-certification

Procedure for revalidation of a certificate by examination or by otherwise satisfying the certification body that the published criteria for re-certification are satisfied.

4.25 Sector

A particular section of industry or technology where specialized NDT practices are used, requiring specific product-related knowledge, skill, equipment, or training

- Ex-product sector (welds, forgings, castings), and the industrial sector (aerospace, in-service testing).

4.26 Significant interruption

Absence or change of activity that prevents the certified individual from practising the duties corresponding to the level in the method and the sector(s) within the certified scope for either a continuous period over one year or two or more periods for a total time exceeding two years.

Note: Legal holidays or periods of sickness or courses of less than 30 days are not considered when calculating the interruption.

4.27 Specific examination

Written examination at Level 1 or Level 2 concerned with testing techniques applied in a particular sector(s), including knowledge of the product(s) tested and of codes, standards, specifications, procedures, and acceptance criteria.

4.28 Specimen

The sample used in practical examinations, possibly including radiographs and data sets, represents products typically tested in the applicable sector.

Note: A specimen can include more than one area or volume to be tested.

4.29 Specimen master report

The model answer indicates the optimum result for a practical examination given a defined set of conditions (equipment type, settings, technique, specimen, etc.) against which the candidate's test report is graded.

4.30 Supervision

Act of directing the application of NDT performed by other NDT personnel, which includes the control of actions involved in the preparation of the test, performance of the test, and reporting of the results.

4.31 Validation

Act of demonstrating that a verified procedure works in practice and fulfils its intended function, generally achieved by actual witnessing, demonstration, field or laboratory tests, or selected trials.

5 FURTHER INFORMATION

NDT practitioners and other interested parties seeking more information or current application forms are asked to contact:

For certification:

Mrs. Prathibha Wimalasiri

OIC-Certification Unit, NCBNDT

Phone: +94 -112987854 Ext: 323
Fax: +94-11-2987851
Email: cbndt@aeb.gov.lk

For examination:

Mr. Chandana Seneviratne–Deputy Chairman or
Ms. Buddhi Weerasinghe–Assistant Deputy Chairman
Examination Committee, NCBNDT

Phone: +94 -112987854 Ext: 302 or 322
Fax: +94-11-2987851
Email: cbndt@aeb.gov.lk

Operational Address

National Certification Body for Non-Destructive Testing (NCBNDT),

C/O: National Centre for Non-Destructive Testing,
977/18, Bulugaha Junction,
Kandy Road, Kelaniya, Sri Lanka.

Also, application forms and other relevant documents can be downloaded from the NCBNDT web page. (www.aeb.gov.lk/CBNDT)

6 RESPONSIBILITIES

6.1 Responsibilities of the NCBNDT

The NCBNDT conducts qualification and certification activities satisfying all the requirements of ISO/IEC 17024 and ISO 9712 without any commercial or other pressures and maintaining impartiality, transparency, integrity, and confidentiality.

6.2 Responsibilities of the Employer

- The employer shall release the candidate from their normal duties for the NDT training and qualification examination.
- The employer shall confirm the validity of the candidate's personal information (education, training, and experience) provided to the NCBNDT.
- Shall facilitate to fulfill an annual test of visual acuity of candidates.
- Shall verify documentary evidence of industrial experiences gained under qualified supervision by the candidate.
- Shall verify continuity in the application of the NDT method without any significant interruption by the candidate.
- Shall ensure that the certified personnel hold a valid certification and obtain approvals relevant to their tasks within the organization.
- Shall supervise the maintaining of appropriate records on industrial experiences by the candidate.

Note: If the candidate is unemployed or self-employed, the declaration of education, training, and experience shall be attested to by one or more independent parties.

6.3 Responsibilities of the Candidate

Candidates shall provide the following evidence regarding the relevant NDT method, level, and sector of certification sought within two (02) years from the date of qualification examination:

- Documentary evidence of satisfactory completion of the training course.
- Evidence of successful completion of the qualification examination (qualification examination certificate or a letter given by the qualifying body).
- Documentary evidence that the required industrial experience has been gained under qualified supervision.
- Vision test results obtained within one (01) year period.

6.4 Responsibilities of the Certificate Holder's

Certificate holders shall:

- Abide by the code of ethics published by the NCBNDT
- Undergo an annual visual acuity test, and submit the test results to the employer.
- Notify the NCBNDT and the employer if the conditions for validity of certification are not fulfilled.

7 QUALIFICATION LEVELS OF NDT

7.1 Level 1

An individual certified to level 1 has demonstrated competence to carry out NDT according to written instructions and under the supervision of level 2 and level 3 personnel. Within the scope of the competence defined on the certificate, Level 1 personnel may be authorized by the employer to perform the following in accordance with NDT instructions:

- Set up NDT equipment
- Perform the tests.
- Record and classify the results of the test according to written criteria.
- Report the results.

Level 1 certified personnel shall neither be responsible for the choice of test method or technique to be used-nor for interpreting test results.

7.2 Level 2

An individual certified to level 2 has demonstrated competence to carry out NDT according to NDT procedures. Within the scope of the competence defined on the certificate, Level 2 personnel may be authorized by the employer to:

- Select the NDT technique for the testing method to be used.
- Define the limitations of the application of the testing method.
- Translate NDT codes, standards, specifications, and procedures into NDT instructions adapted to the actual working conditions.
- Set up and verify equipment settings
- Perform and supervise tests.
- Interpret and evaluate results according to applicable standards, codes, specifications, or procedures.
- Carry out and supervise all tested at or below level2.
- Provide guidance for personnel at or below level 2.
- Report the results of NDT.

7.3 Level 3

An individual certified to level 3 has demonstrated competence to perform and direct NDT operations for which he is certified. Level 3 personnel have demonstrated:

- The competence to evaluate and interrupt results in terms of existing standards, codes, and specifications.
- Sufficient practical knowledge of suitable material, fabrication, process, and product technology to select NDT methods, establish ND techniques, and assist in establishing acceptance criteria where none are otherwise available.
- A general familiarity with other NDT methods.

Within the scope of the competence defined on the certificate, certified level 3 personnel may be authorized to:

- Assume full responsibility for a test facility or examination center and staff
- Establish, review editorial and technical correctness, and validate NDT instructions and procedures.
- Interpret standards, codes, specifications, and procedures
- Designate the particular test methods, procedures, and NDT instructions.
- Carry out and supervise all tasks at all levels.
- Provide guidance for NDT personnel at all levels.

8 NDT QUALIFICATION AND CERTIFICATION

8.1 Currently Available NDT Qualifications and Certifications

Currently, available NDT qualifications and certifications at NCBNDT describes in the "Scope of NCBNDT, Sri Lanka", as mentioned in Appendix 01 of this document.

8.2 NDT Certification

The candidate may apply for certification as per the "Scope of NCBNDT, Sri Lanka" (Ref: Appendix 01). They are expected to finalize certification no later than two (02) years from the date of successful completion of the qualification examination. Otherwise, they have to re-sit for the practical examination in the relevant sector, method, and level to re-qualify (Ref: Appendix02 "Process of the Qualification, Certification, and Re-qualification"). Here level 2 practical examination is except for the drafting of NDT Instruction Writing. The candidates lacking the required industrial experience and satisfy all other basic requirements for NDT certification, as mentioned in clause no 10.4, are encouraged to apply for certification, and the NCBNDT offers "Trainee" status for them.

8.3 Certification Requirements

All candidates shall abide by the code of ethics published by the certification body. They shall fulfil the following requirements to be eligible for the initial certification as specified in ISO 9712;

- Vision requirements
- Adequate NDT training
- Satisfactory performance in qualification examination (Written and Practical)
- Adequate industrial experience

The completed certification application form (Ref: NCBNDT/FRM/CA) shall be submitted to the CU of NCBNDT with a passport size quality photograph by hand, post or via e-mail.

Postal Address:

OIC - Certification Unit, National Certification Body for NDT - Sri Lanka,
C/O; National Centre for Non-Destructive Testing (NCNDT),
No.977/18, Bulugaha Junction,
Kandy Road, Kelaniya.

8.4 Vision Requirements

The candidate seeking certification in any sector, method, and level shall provide documentary evidence of satisfactory vision as per the NCBNDT format (Ref: CBNDT/FRM/EER) from an optometrist or another competent person in accordance with the following requirements:

- Near vision acuity shall permit reading a minimum of Jaeger number 1 or Times New Roman N 4.5 or equivalent letters (having a height of 1.6 mm) at not less than 30 cm with one or both eyes, either corrected or uncorrected;
- Colour vision shall be sufficient that the candidate can distinguish and differentiate contrast between the colours or shades of grey used in the NDT method concerned, as specified by the employer.

Note: Company in-house vision test certificates will be accepted by NCBNDT once the company test procedure has been provided to the NCBNDT for review and approval. This procedure must identify the company officer(s) responsible for the vision testing scheme, and all in-house certificates must be signed by a responsible officer.

Subsequent to certification, visual acuity shall be carried out annually and verified by the employer.

9 NDT TRAINING

For all levels, the candidate shall satisfactorily complete a theoretical and practical training course recognized by the NCBNDT in the relevant NDT method and sector in accordance with the requirements of ISO 9712 prior to qualification examination to be eligible for certification.

Note: These training organizations shall use the NCBNDT approved training syllabus, i.e. Appendix 3-7 in "Training Guidelines in Non-destructive Testing Techniques-2013 Edition (IAEA-TECDOC-628/Rev. 3)" and ISO/CD/TR 25107:2006, Non-destructive testing — Guidelines for NDT training syllabuses.

Further, the training organization is expected to have appropriate equipment(Ref: Appendix 8) available for training purposes and to provide the information regarding the lecture hours, used course notes, syllabus followed, and other relevant information. This recognized training organization shall provide a participation letter to each candidate who has successfully completed the training with the signature of the responsible officer of the training organization.
The minimum duration of training undertaken by the candidate for certification in a particular NDT method and level is given in Table 1. Training hours include both theoretical and practical courses.

Table 1 - Minimum Training Requirements

NDT method	Level 1/ (hours)	Level 2/ (hours)	Level 3/ (hours)
Eddy Current Testing (ET)	40	48	48
Magnetic Particle Testing (MT)	16	24	32
Liquid Penetrant Testing (PT)	16	24	24
Radiography Testing (RT)	40	80	40
Ultrasonic Testing (UT)	40	80	40
Visual Testing (VT)	16	24	24
Note: For RT, training hours do not include radiation safety training			

Direct access to level 2 requires the total hours shown in Table 1 for levels 1 and 2. Direct access to level 3 requires the total hours shown in Table 1 for levels 1, 2, and 3. Additional training about the other NDT methods may be necessary when considering Part C of the Basic Examination for level 3.
The use of a logbook would assist candidates in maintaining detailed records of their training.

9.1 Possible Reductions for the Training Duration

Several reductions in training duration are applicable, and the total reduction does not exceed 50% of the training period. Furthermore, any reduction requires acceptance by the NCBNDT.

- for all levels:
  - For candidates seeking certification in more than one method (e.g. MT, PT), or for those already certified and seeking certification in another method, when the training syllabus concerned duplicates certain aspects (e.g. product technology), the total number of training hours for these methods (e.g. PT, MT, VT) may be reduced in line with the training syllabus.

  - For candidates who have graduated in a relevant subject from a technical college or university, or have completed at least two (02) years of relevant engineering or science study at a college or university, the total required number of training hours may be reduced by up to 50%.

  Note: It is appropriate for the subject to be relevant to the NDT method (chemistry, mathematics, or physics) and/or to the product or industry sector (chemistry, metallurgy, engineering, etc.)

For direct access to level 2 RT, when certification is restricted to the film interpretation and only one product sector, a minimum training requirement of 56 hours applies.

10 INDUSTRIAL NDT EXPERIENCE

10.1 Industrial Experience for Qualification;

For all levels, the minimum period of industrial experience to be gained in the relevant methods and levels prior to the qualification examination shall be as given in Table 2.

Table 2: Minimum Industrial Experience for Qualification

Level	Percentage of the Total Requirement in Table 3	ET, RT, UT Experience/ (hours)	MT, PT, VT Experience/(hours)
1	0%	0	0
2	10%	192	64
3	10%	480	256

10.2 Industrial Experience for Certification

The candidate is required to have a period of experience relevant to the certification sought in addition to any experience gained during training courses, such as practical training time.

Accordingly, candidates shall maintain an "Industrial Experience Log Book" on the method of applying for certification. The industrial experience in the relevant method shall be obtained under qualified supervision.

Note: The qualified supervision is the supervision of candidates in acquiring experience through NDT personnel, who are certified in the same way or by personnel who have the knowledge, skills, training, and experience necessary for the correct performance of such oversight.

- All candidates (either employed, self-employed or unemployed) must have verifiable evidence that they have acquired the necessary experience under qualified supervision.
- The experience summary on the certification application form (Ref: CBNDT/FRM/CA) shall be confirmed by the employer or the qualified supervisor.
- Instructions for employers are available on the NCBNDT web page (Ref: CBNDT/INF/EMP)
- If the candidate is unemployed, the declaration of the experience must be confirmed by at least one independent party. The following acknowledgements are accepted by the NCBNDT:
- Confirmations by the former employer, temporary employment agencies, internships at accredited training organizations, etc.
- If the candidate is self-employed, the declaration of the experience must be confirmed by at least one independent party. The following acknowledgements are accepted by the NCBNDT:
- Confirmations by the former employer, customer, client, temporary employment agencies, internships at accredited training organizations, etc.

The minimum period of industrial experience to be gained in the relevant methods and levels of certification shall be as given in Table 3.

Table 3 - Minimum Industrial Experience for Certification

NDT method	Experience/(months)		Experience/(hours)	
	ET, RT, UT	MT, PT, VT	ET, RT, UT	MT, PT, VT
Level 1	3	1	480	160
Level 2 access as level 1	9	3	1440	480
Level 2 direct access	12	4	1920	640
Level 3 access as level 2 (Type 1)	18	12	2880	1920
Level 3 access as level 2 (Type 2)	36	24	5760	3840
Level 3 access as level 1 (Type 1)	27	15	4320	2400
Level 3 access as level 1 (Type 2)	45	27	7200	4320
Industrial experience in months is based on a nominal 40h per week or the legal week of work. When individual works above 40 h per week, the individual may be credited with experience based on the total hours. However, he/she shall be required to produce evidence of this experience.				

- When a candidate seeks certification in more than one method, the total time of experience shall be the sum of the experience in each method.

10.2.1 For level 2 certification

- Industrial experience is the work performed as a level 1 qualified. If the individual is being qualified directly to level 2, with no time at level 1, the experience shall consist of the sum of the times required for level 1 & level 2. In this case, no reduction in the period of experience is allowed.
- If a part of the experience is sought following successful examination, the examination results shall remain valid for two (02) years or for the total experience time required for the methods concerned, whichever is greater.

10.2.2 For level 3 certification

i. Level 3 responsibilities require knowledge beyond the technical scope of any specific NDT method.
ii. This broad knowledge may be acquired through various combinations of education, training, and experience.
iii. Level 3 candidates are categorized into two types, as mentioned in Table 4.
iv. Table 3 describes the minimum experience for level 3 candidates of Type 1 and Type 2.

v. For Level 3 certification, the industrial experience is the work performed as a level 2. If the individual is being qualified directly from level 1 to level 3, with no time at level 2, the experience shall consist of the sum of the times required for level 2 & level 3. In this case, no reduction in the experience period is allowed.

Table 4: Level 3 Candidates Categorization

Type 1	Candidates who have successfully completed a technical school or at least two (02) years of engineering or science study at an accredited college or university.
Type 2	Candidates who have not successfully completed a technical school or at least two (02) years of engineering or science study at an accredited college or university.

10.3 Possible Reduction

i. The possible reductions in the duration of experience are as described hereafter, provided that, when several reductions are applicable, the total reduction does not exceed 50% of the experience duration. Any reduction does require acceptance by the NCBNDT.

ii. Credit for industrial experience may be gained simultaneously in two or more of the NDT methods, with the reduction of the total required experience as follows:
- Two (02) testing methods: reduction of the total required time by 25 %;
- Three (03) testing methods: reduction of the total required time by 33 %;
- Four (04) or more testing methods: reduction of total time by 50 %.

- Ex: If a candidate holds a certification in MT and PT and is gaining experience in UT, this would result in a 33% reduction in the UT experience required.

iii. The duration of experience gained from the internship experience programme may be multiplied by a factor of 5 when calculating qualifying working experience.

- Up to 50% of the practical experience time may be achieved by an appropriate practical course. The duration of which may be weighted by a maximum factor of 5.
- The course shall concentrate on practical solutions to frequently occurring testing problems and should involve a significant element of testing known defective specimens. The programme shall be approved by the certification body.

- Ex: If a 2-day practical workshop is completed, it can be multiplied by five (05) to count for ten (10) days (i.e., 80 h) of qualifying work experience.

iv. In all cases, for each NDT method and sector combination for which the candidate seeks certification, he/she shall have at least half of the experience required, and this shall never be less than one month in duration.

v. When the certification sought is limited in application (e.g. thickness measurement), experience duration may be reduced by up to 50 % but shall not be less than one month.

10.4 Lack of Industrial Experience

i. If a candidate lacks the minimum industrial experience requirement but has received the relevant training and has demonstrated competence by qualifying for the examinations, they may request to be granted "Trainee" status by submitting the "Application Form for Trainee" (Ref: CBNDT/FRM/TRA) within two (02) years from the date of qualification examination and have certification deferred.

ii. The "Trainee" status is valid for five (05) years from the date of successful completion of the qualification examination. Candidates who require more than two (02) years to acquire the required minimum industrial experience hours will have to demonstrate to the TAC that they have not had a significant interruption, i.e. a period of twelve (12) months or more in the application of the NDT method. Otherwise, a re-sit of the practical examination will be required.

iii. Trainees may accumulate industrial experience over a five (05) year period but must finalize certification before five (05) years have elapsed from the first examination date.

iv. It is the responsibility of the "Trainee" to inform the NCBNDT of experience gained whilst holding that status. Once the NCBNDT has received evidence from the candidate that the minimum number of hours has been satisfied, the "Trainee" status will be upgraded to full certification with an expiry date of five (05) years from the date they had granted the "Trainee" status.

v. If, after five (05) years, the trainee has not finalized his certification, the application will lapse, and he/she must apply for certification as a new candidate.

11 ARRANGEMENTS OF NDT EXAMINATIONS

The Examination Committee (EC) of NCBNDT offers NDT qualification examinations as per the "Scope of NCBNDT, Sri Lanka" (Ref: Appendix 01) only for the candidates who have met the following minimum requirements before the qualification examination.

- Comply with the minimum requirements for the NDT training as defined in Table 1 of this guide.
- Meet the minimum requirements on the vision as defined in clause no 8.4 of this guide.

The EC of NCBNDT publishes the schedule of original qualification examinations at the beginning of each year in conjunction with the training schedule of the Training Unit (TU) of NCNDT. Unscheduled original qualification examinations can be arranged for a group of candidates in conjunction with the unscheduled training courses at NCNDT. Further, re-examinations, re-qualification examinations, and re-certification examinations can be conducted upon request from the candidates.

Both written and practical examinations are generally held at the NCNDT examination centers. If any interested party needs to conduct examinations at their premises, a written request shall be made to the Chairman of EC. Usually, test equipment available at NCNDT laboratories is used to conduct practical examinations. Although with the written approval of the NCBNDT, a candidate for a practical examination may use his equipment.

The NCBNDT defines the maximum amount of time allowed for the candidate to complete each examination based on the number and difficulty of the questions. The average time allowed is not longer than three (03) minutes per multiple-choice question having 04 answers. The examination medium is English. Any candidate

whose English is not the mother language may request an additional fifteen (15) minutes to complete any examination. The candidate who applies for RT practical examination shall wear a Thermo Luminescence Dosimeter (TLD) provided by the Radiation Protection Officer (RPO) of NCNDT when doing the practical examination.

All candidates are required to submit the completed "Examination Application Form" along with the "Eye Examination Report" to the Management Assistant (MA) of EC before commencing the examination. Furthermore, candidates are responsible for collecting "Examination Guidelines" (Ref: Appendix 9), "Examination Agreement" (Ref: CBNDT/FMT/EC/EAG), and "Examination Admission" (Ref: CBNDT/FMT/EC/EAD) before the examination from the MA of EC. A candidate must follow all the instructions given in the "Examination Guidelines" and must accept all the terms and conditions in the "Examination Agreement". Otherwise, he/she will not be permitted to take the requested examination.

12 REQUIREMENTS FOR NDT EXAMINATIONS

12.1 Requirements for ISO 9712 - Level 1 and Level 2

Examination requirements for level 1 and level 2 certifications comprise:

- General Examination
- Specific Examination
- Practical Examination

12.1.1 General Examination – Level 1 and Level 2

This examination tests the candidate's knowledge of the theory and general applications of the particular NDT method. This paper consists of Multiple Choice Questions (MCQs) to be answered on the examination paper or a separate answer sheet given by the EC.
The general examination includes only questions selected in an unpredictable way from the NCBNDT's collection of general examination questions valid at the date of examination and/or from the ICNDT question bank questions valid for the particular examination.

ET/RT/UT : 40 questions minimum
MT/PT/VT : 30 questions minimum
Duration : 2 hours maximum
Pass Mark : 70%

There is an additional examination on Radiation Safety for the RT in both level 1 and level 2.

Examination of the RT method includes either X-ray or gamma-radiation or both depending upon the procedure of the NCBNDT.

12.1.2 Specific Examination– Level 1 and Level 2

This examination tests the candidate's knowledge of the industrial sector and the application of the NDT method to the specific field of non-destructive testing (product sector). Further, a specific examination paper comprises

questions involving calculations, NDT procedures, and questions on codes, standards, and specifications. This paper consists of MCQs to be answered on the examination paper or a separate answer sheet given by the EC. The specific examination includes only questions selected in an unpredictable way from the NCBNDT's collection of specific examination questions valid at the date of examination and/or from the ICNDT question bank questions valid for the particular examination.

ET/RT/UT/MT/PT/VT : 20 questions minimum or
30 questions minimum (if the specific examination covers two or more sectors)
Duration : 1.5 hours maximum
Pass Mark : 70%

12.1.3 Practical Examination – Level 1

This examination requires the practical application of the NDT method to the industry sector for which the application is made. The practical examination may include any or all (but is not limited to) of the following requirements:

- Follow the NDT instruction(s) provided by the Examiner.
- Demonstrate the ability to set up and calibrate the equipment and verify its sensitivity.
- Recognize the discontinuities as shown by the test.
- Record the test data.
- Accurate reporting concerning geometry, location, and sizing revealed by the NDT instruction**.**

Duration and Assessment

- Duration for ET/RT/UT/MT/PT/VT: 4 hours maximum
- There is only one section in the level 1 practical examination, i.e. Section 1 (inspection and reporting of a minimum of two (02) specimens as given in Appendix 14).
- Candidates who fail to report mandatory reportable discontinuities of the specimen tested will not be granted a pass in the practical examination.
- Minus marks may be added to the candidates who report excessive false calls (reporting of non-existent discontinuities) in the practical examination.
- A minimum pass mark of 70% is required in each specimen tested in Section 1.
- A candidate with less than 70% marks in the practical examination of a particular specimen needs to sit for a re-examination of Section 1, i.e. two (02) specimens required.

Example: MT1 – Sector Designator - MT1PI, MS - Practical Examination

Section 1: Specimens
Specimen 1: 80%
Specimen 2: 63%

Overall Result: Refer/Fail, as a minimum of 70% in each specimen not achieved.

Re-examination Required:
Re-examination of Section 1: Two (02) specimens required

12.1.4 Practical Examination – Level 2

This examination requires the practical application of the NDT method to the industry sector for which the application is made. The practical examination may include any or all (but is not limited to) of the following requirements:

- Select the applicable NDT technique and determine the operating conditions related to a given code, standard, or specification.
- Demonstrate the ability to interpret and evaluate previously recorded test data.
- Interpretation of radiographs where applicable.
- Write an instruction in the NDT method and product/industry sector for a level 1 operator.
- Detailed description and illustration of the equipment set-up and/or test procedure and test parameters for a particular application.
- The recognition and identification of discontinuities as shown by the test, which includes general knowledge of the mechanism giving rise to the discontinuities.
- Accurate reporting concerning geometry, location, and sizing according to the test procedure.

Duration and Assessment

- Duration for ET/RT/UT/MT/PT/VT: 6 hours maximum
- Generally, the level 2 practical examination is broken into two (02) sections:
  Section 1 – Specimens (inspection and reporting of minimum two (02) specimens as given in Appendix 14)
  Section 2 – Development of NDT Instruction Writing
- For RT level 2 practical examination, there is another section in addition to the above two (02) sections, i.e. Section 3 – Radiographic Interpretation (A set of radiographs, i.e. 12 or 24, are considered as one specimen)
- Candidates who fail to report mandatory reportable discontinuities of the specimen tested will not be granted a pass in the practical examination.
- For RT, this condition applies to radiographic interpretation, i.e. failing one "mandatory to report" discontinuity on one radiograph leads to zero marks for the set of radiographs in Section 3.
- Minus marks may be added to the candidates who report excessive false calls (reporting of non-existent discontinuities) in the practical examination.
- A minimum pass mark of 70% is required in each specimen tested and section.
- A candidate who has less than 70% marks in the practical examination of a particular specimen tested or section needs to sit re-examination of that particular section.

Example: MT2 – Sector Designator - MT2PI, MS - Practical Examination

Section 1: Specimens
Specimen 1: 65%
Specimen 2: 90%

Section 2: Development of NDT Instruction Writing

Grade: 85%

Overall Result: Refer/Fail, as a minimum of 70% in each specimen and section not achieved.

Re-examination Required:
Re-examination of Section 1: Two (02) specimens required

12.1.5 Examination Exemptions – Level 1 and Level 2

A certified level 1 or level 2 individual changing sectors or adding another sector for the same NDT method shall be required to take only the new sector-specific and practical examinations for that method.

12.2 Requirements for ISO 9712 – Level 3

All candidates for level 3 certification in any NDT method shall have completed (with a grade of ≥ 70 %) the practical examination for level 2 in the relevant sector and method, except for the drafting of NDT instructions for level 1.

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 NDT method in an industrial sector is exempt from passing the level 2 practical examination again.

This exemption is only valid for the product sectors covered by the industrial sector concerned. In any other circumstances, the relevant sector is the sector in which the candidate seeks level 3 certification.

12.2.1 Basic Examination

This written examination assesses the candidate's knowledge of the basic subjects using at least the number of multiple-choice questions shown in Table 5. Examination questions are selected unpredictably from the current collection of questions approved by the NCBNDT at the time of the examination and/or ICNDT question bank questions valid for the particular examination.

Table 5: Minimum Required Number of Basic Examination Questions

Part	Subject	Number of Questions
A	Technical knowledge in materials science and process technology.	25
B	Knowledge of the certification body's qualification and certification system based on the ISO 9712. This part may be an open book examination.	10
C	General knowledge of at least four (04) methods as required for level 2 and chosen by the candidate from the methods given in Clause 1 on the ISO 9712. These four (04) methods shall include at least one volumetric method (UT or RT).	15 for each test method (total 60)

Duration and Assessment

- Duration: 3 hours maximum
- Pass Mark: 70% in each of the above three (03) parts

12.2.2 Main Method Examination

This written examination assesses the candidate's knowledge of the main method subjects using the minimum required number of multiple-choice questions shown in Table 6. Examination questions are selected unpredictably from the current collection of questions approved by the NCBNDT at the time of the examination and/or ICNDT question bank questions valid for the particular examination.

Table 6: Minimum Required Number of Main Method Examination Questions

Part	Subject	Number of Questions
D	Level 3 knowledge relating to the test method applied.	30
E	Application of the NDT method in the sector concerned, including the applicable codes, standards, specifications, and procedures. This part may be an open book examination of codes, standards, specifications, and procedures.	20
F	Drafting of one or more NDT procedures in the relevant sector. The applicable codes, standards, specifications, and other procedures are available to the candidate. For a candidate who has already drafted an NDT procedure in a successfully passed level 3 examination, the certification body may replace the drafting of a procedure with the critical analysis of an existing NDT procedure covering the relevant method and sector, and containing errors and/or omissions.	-

Duration and Assessment

- Duration: Part D – 1 hour maximum
  Part E – 1 hour maximum
  Part F – 3 hours maximum
- Pass Mark: 70% in each of the above three (03) parts

12.2.3 Examination Exemptions

It is recommended that the basic examination be passed first and remain valid, provided that the first main method examination is passed within five (05) years after passing the basic examination.

A candidate, who has a valid and recognized ISO 9712 level 3 certificate, is exempt from the need to retake the basic examination when seeking level 3 certification in another NDT method.

A certified level 3 individual changing sectors or adding another sector in the same NDT method does not need to retake the basic examination or the level 3 knowledge relating to the test method of the main-method examination.

12.3 Re-examinations

Suppose a candidate who is unable to obtain the passing grade for any examination part may be re-examined twice (02) in the referred parts. However, the re-examination shall take place no sooner than one (01) month unless further training acceptable to the certification body is satisfactorily completed, nor later than two (02) years after the original examination.

A candidate who is unable to pass all permitted re-examinations shall apply for and take the examination following the procedure established for new candidates.

12.4 Absence in Examinations

A candidate unable to attend for the complete or part of the original qualification examination for any reason (medical/other) is considered as not completed the examination and shall complete the full qualification examination within the next two attempts.

A candidate unable to attend for the complete or part of the 1st re-examination for any reason (medical/other) is considered as not completed the 1st re-examination and shall complete the full examination within the next attempt.

A candidate unable to attend for the complete or part of the 2nd re-examination for any reason (medical/other) is considered as not completed the 2nd re-examination and shall complete the full examination as a new candidate.

13 INITIAL NDT CERTIFICATION

The NCBNDT grants certification to any candidate who successfully fulfills all the certification requirements. The NCBNDT issues a hard copy certificate (Ref: Format of the certificate – Appendix 10) to each certified individual and displays relevant information about the certified individuals on the certification body's website.

13.1 Validity

Certifications are valid from the date of issue and up to five (05) years from the issue date when all of the requirements for certification (training, experience, vision certificate, and success in examination) are fulfilled. The issue date is defined as the date that obtains approval from the Council of NCBNDT for the certification.

Certification becomes invalid:

- At the discretion of the NCBNDT, e.g. after reviewing evidence of behaviour incompatible with the certification procedures or failure to abide by a code of ethics;
- If the individual becomes physically incapable of performing his/her duties based upon the failure of the visual acuity examination taken annually under the responsibility of his/her employer;
- If significant interruption takes place in the method for which the individual is certified;
- If the individual fails re-certification, until such times as the individual meets the requirements for re-certification or initial certification.

13.2 Revalidation

The conditions for revalidation are defined in the "Code of Ethics" defined by the NCBNDT (Ref: Appendix 11). After a significant interruption, the individual shall pass a recertification examination to revalidate the certification. The certification is revalidated for a new period of validity of five (05) years from the revalidation date.

14 RENEWAL OF NDT CERTIFICATION

Prior to the completion of the first period of validity, i.e. five (05) years from the issued date of the certification certificate, and every ten (10) years thereafter, certification may be renewed by the NCBNDT for a new period of five (05) years on production of:

a. Documentary evidence of a satisfactory visual acuity examination taken within the preceding twelve (12) months (the vision certificate must be submitted as a copy, and the original is to archive with the employee)
b. Verifiable documentary evidence of continued satisfactory work activity without significant interruption in the method and sector for which certificate renewal is sought.

If the criterion (b) for renewal is not met, the individual shall follow the same rules as for recertification.

It is the responsibility of the certificate holder to submit a completed renewal application with all supporting documentation to the OIC-Certification Unit of NCBNDT six (06) months prior to the expiry date of the current certification.

The expiry date of the renewed certificate will be five (5) years from the expiry date of the initial certification period. That is ten (10) years from the issue date of the initial certification.

As an exemption, renewal applications received within twelve (12) months from the expiry date may be considered. In such a case, the certified individual shall submit a written explanation describing the reason for late submission along with the renewal application form.

If a certificate holder applies for the renewal after a twelve (12) months period from the expiry date, any exemption is not allowed, and he/she shall follow the same rules as for re-certification.

15 RE-CERTIFICATION OF NDT CERTIFICATION

Prior to completing the second period of validity (every ten (10) years), the certified individual may be recertified by the CBNDT for a new period of five (05) years.

i. All information necessary for re-certification (instruction sheet for certification application, re-certification application form, application for NDT re-certification examination, and eye examination

report form) is available on the official website of the Sri Lanka Atomic Energy Board (http://www.aeb.gov.lk/).

ii. It is recommended to submit the recertification examination application and recertification application six (06) months prior to the expiration date of the certification or at least within twelve (12) months from the expiry date.

iii. If the recertification is applied for more than twelve (12) months after the expiry of the period of validity, an examination shall again be successfully passed as given below.

- For level 1 and 2: a complete examination (general, specific, and practical)
- For level 3: the main method examination (part D, E, and F) [The examination of basic knowledge (part A, B, and C) for level 3 is excluded.]

15.1 Re-certification of Levels 1 and 2

15.1.1 The individual shall produce verifiable documentary evidence of continued satisfactory work activity without significant interruption in the method and sector for which the recertification is sought.

15.1.2 The individual shall successfully complete a practical examination which demonstrates continued competence to carry out work within the scope of the certificate. This examination includes testing specimens (Ref: Appendix 12) appropriate to the scope of certification to be recertified. For level 2, the production of a written instruction suitable for the use of level 1 personnel is required.

15.1.3 If the individual fails to achieve a grade of at least 70% for each specimen tested and instruction writing at level 2, two (02) re-examinations of the whole recertification examination are allowed after at least seven (07) days and within six (06) months of the first attempt at the recertification examination.

15.1.4 If the candidate fails in the two allowable re-examinations, the certification is not revalidated. Then the candidate shall apply for a new certification to regain certification for that level, sector, and method. In this case, no examination exemptions are awarded by virtue of any other valid certification held.

15.2 Re-certification of Level 3

15.2.1 Level 3 certificate holders seeking re-certification shall provide evidence of continued qualification confirmed by:

- Satisfying the level 3 requirements for (15.6) a written examination.
- Meeting the requirements for a structured credit system, as given in Appendix 13

15.2.2 The certified person may decide between the written examination or credit system for recertification.

15.2.3 When the credit system is selected, the delivery of documents of the employer or the access is required to the premises of the employer. The individual shall provide the NCBNDT with a written statement of approval from the employer for accessing the employer's premises and related documents.

15.2.4 In both cases (written examination and credit system), the individual shall either:

- Provide appropriate documented evidence of his continued practical competence in the method or pass a level 2 practical examination, as in 12.1.4, except for the drafting of NDT instructions.

15.2.5 The following three (3) combinations are accepted by the NCBNDT for recertification in level 3:

- Level 3- Combination 1: Written exam + level 2 practical exam except drafting of NDT instructions
- Level 3- Combination 2: Written exam + documented evidence of continued practical competence
- Level 3- Combination 3: Structured credit system + level 2 practical exam except drafting of NDT instructions

Note: Based on the combination of "structured credit system" + "proof of continuing practical ability", the NCBNDT recertification is not possible.

15.2.6 If the credit system is chosen and requires submission of the employer's documents or access to the employer's premises, the individual shall provide the NCBNDT with a written statement of approval from the employer.

15.2.7 Appropriate written proof of continuing practical ability-The practical skills must be proven by documents. These documents must be entered on the appropriate form and be confirmed by the employer or by a person authorized by the employer. If the logbook or related documents are not submitted, they are required to be filed with the employer, and access should be granted if required by the NCBNDT.

15.2.8 At least five (5) years of evidence between renewal and recertification is required. The document must be available for each calendar year. The temporal distance between the individual documents may not exceed fourteen (14) months.

15.2.9 An individual candidate who applies for and does not meet the requirements of the credit system shall apply for re-certification in accordance with 15.5.5. In the event of a failure at the first attempt at recertification by examination, only one re-examination of the recertification examination is allowed within twelve (12) months of the date of application for recertification via the structured-credit system.

15.3 Written Examination

15.3.1 The individual shall successfully complete an examination that includes a minimum of twenty (20) questions on the application of the test method in the sector(s) concerned, which demonstrates an

understanding of current NDT techniques, standards, codes or specifications, and applied technology and, five additional questions on the requirements of the certification scheme.

15.3.2 If the individual fails to achieve a grade of at least 70 % in the recertification examination, a maximum of two re-examinations of the recertification examination is allowed within twelve (12) months of the first attempt during the recertification examination. This twelve (12) months period may be extended by the NCBNDT.

- In the event of a failure in the two allowable re-examinations, the certificate shall not be revalidated. In order to regain certification for that sector and method, the candidate shall be required to succeed in the appropriate main method examination (parts D, E, and F).

16 FEES

Fees for initial certification, renewal, re-certification and examination, along with their application forms and eye examination reports are available at www.aeb.gov.lk

- The fee shall be drawn in favour of "Chairman, Sri Lanka Atomic Energy Board."

Address: National Centre for Non-Destructive Testing,
Sri Lanka Atomic Energy Board,
977/18, Bulugaha Junction, Kandy Road, Kelaniya.

17 CERTIFICATION WITHDRAWAL

i. Certificate holders shall sign the agreement with NCBNDT.

ii. Should a complaint of a Code of Ethics violation or abuse of the requirements for the use of Certificates, Logos/marks be notified to NCBNDT, and the complaint against the Qualified/Certified person be proven by the NCBNDT, Qualification/Certification may be withdrawn for a period at the discretion of the council of NCBNDT.

iii. To regain certification, the person shall apply to the NCBNDT after the expiration of the period of withdrawal as a new candidate and shall pass all relevant examinations for the NDT method/sector.

iv. An appeals committee is available if required by the disqualified person.

18 APPEALS AND COMPLAINTS PROCESS

i. All appeals/complaints must be made in writing and should be similarly acknowledged. Submission, investigation, and decision on appeals/complaints do not result in any discriminatory actions against the appellant.

ii. Appeals/Complaints may be made against a decision taken by the TAC of NCBNDT not to award a certificate, to withdraw or cancel a certificate, or not to renew a certificate.

iii. Any candidate has the right to make an appeal/complaint to review any of his/her answer scripts related to the NDT examination.

iv. A duly completed appeal/complaint form has to be submitted (registered post or by hand) to the Director General of SLAEB within 30 days from the release of examination results (Ref: Appeal Form – Certification CBNDT/FRM/APP).

19 INSTRUCTIONS FOR THE EMPLOYER

i. An employer of NDT personnel carries important responsibilities for the overall quality of NDT operations. These should be reflected in the employer's quality procedure for NDT. The employer retains these responsibilities whether he/she uses third-party certification, in-company certification, or a combination of both.**(** Ref: CBNDT/INF/EMP)

ii. The employer has overall responsibility for the results of NDT operations and is fully responsible for the authorization of the staff to work. In practice, this should include checking that the NDT tasks to be carried out are within the scope of the individual's certification (sector, method, level, and his/her recent experience) and, if they are not, organizing additional company job-specific training and/or examinations.

iii. The employer is responsible for introducing candidates to the certification body and documenting the validity of the personal information provided. This information shall include the declaration of education, training, experience, and visual acuity needed to determine the eligibility of the candidate. (If the candidate is unemployed or self-employed, the declaration of education, training, and experience shall be attested by at least one independent party.)

iv. The employer must ensure that employees meet the visual acuity requirements of the certification body annually and must keep records of work experience that will be needed to demonstrate the continuity of satisfactory work activity without significant interruption. This is important for his quality assurance and to support renewal/recertification.

v. Significant interruption:-Absence or change of activity which prevents the certified individual from practising the duties corresponding to the level in the method and the sector(s) within the certified scope, for

- a continuous period over one year or
- two or more periods for a total time exceeding two years
    - NOTE: Legal holidays or periods of sickness or courses of less than thirty days are not considered.

END

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The Scope of NCBNDT, Sri Lanka

Qualification & Certification of Non-Destructive Testing Personnel as per ISO 9712: 2012

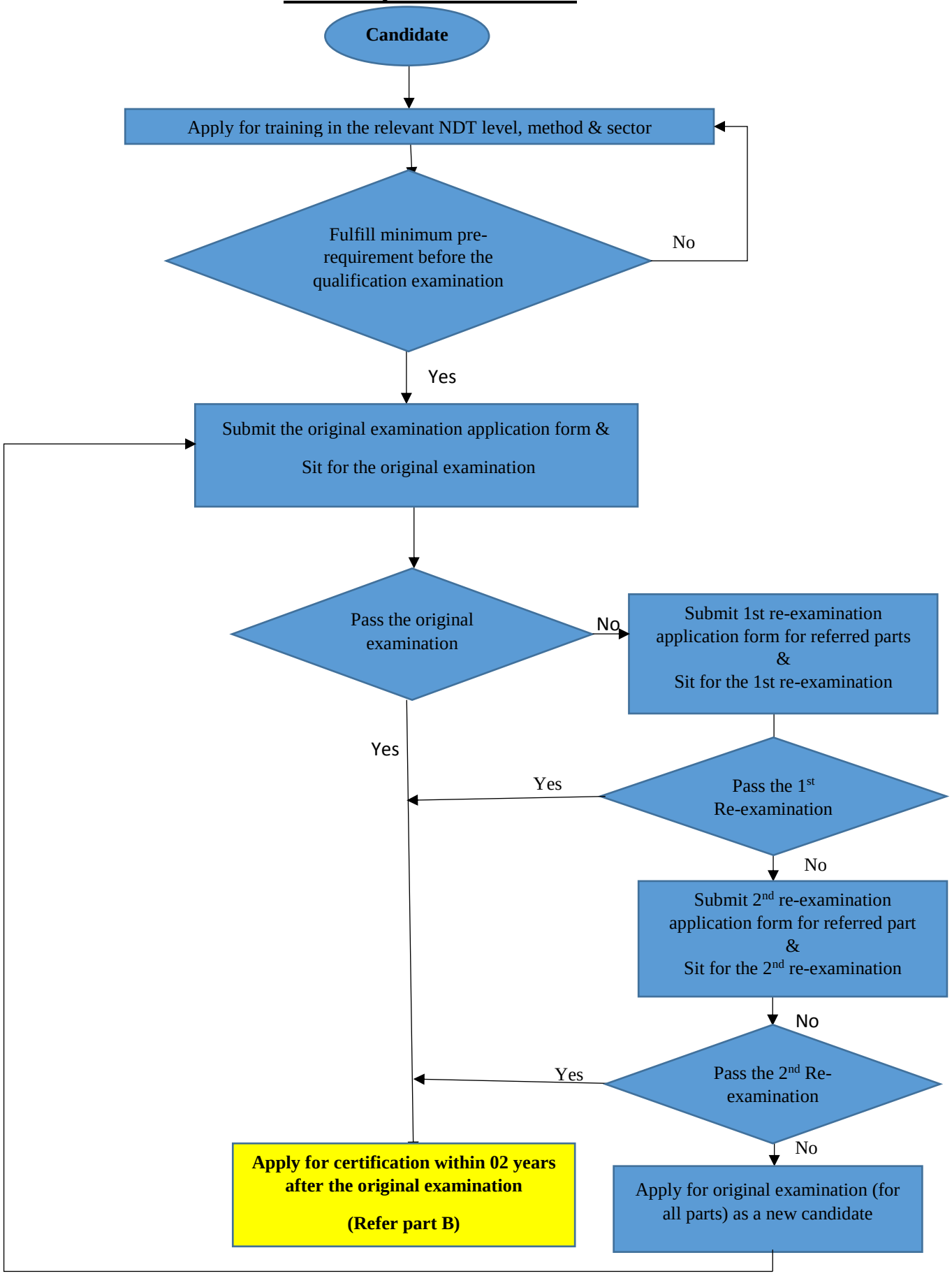
Method	Level	Sector	Designator
ET	1	General Engineering	ET1GE
	2	Pre and In-service, Wrought Products except Forgings	ET2PI, WP
	3	Pre and In-service, Wrought Products except Forgings	ET3PI, WP
MT	1	Pre and In-service, Multi Sector (Welds, Castings, Forgings)	MT1PI, MS
	2	Pre and In-service, Multi Sector (Welds, Castings, Forgings)	MT2PI, MS
	3	Pre and In-service, Multi Sector (Welds, Castings, Forgings)	MT3PI, MS
PT	1	Pre and In-service, Multi Sector (Welds, Castings, Forgings)	PT1PI, MS
	2	Pre and In-service, Multi Sector (Welds, Castings, Forgings)	PT2PI, MS
	3	Pre and In-service, Multi Sector (Welds, Castings, Forgings)	PT3PI, MS
RT-Film	1	Pre and In-service, Welds (Pipe, Plate)	RT-F1PI, BW
	2	Pre and In-service, Welds (Pipe, Plate)	RT-F2PI, BW
		[*1]Pre and In-service, Welds (Pipe, Plate, Tee)	RT-F2PI, BW, T
	3	Pre and In-service, Welds (Pipe, Plate)	RT-F3PI, BW
		[*1]Pre and In-service, Welds (Pipe, Plate, Tee)	RT-F3PI, BW, T
UT	1	General Engineering	UT1GE
	2	Pre and In-service, Welds (Pipe, Plate)	UT2PI, BW
		[*1]Pre and In-service, Welds (Pipe, Plate, Tee, Nozzle)	UT2PI, BW, T, N
	3	Pre and In-service, Welds (Pipe, Plate)	UT3PI, BW
		[*1]Pre and In-service, Welds(Pipe, Plate, Tee, Nozzle)	UT3PI, BW, T, N
VT	1	General Engineering	VT1GE
	2	Pre and In-service, Welds (Pipe, Plate, Tee)	VT2PI, BW, T
	3	Pre and In-service, Welds (Pipe, Plate, Tee)	VT3PI, BW, T

Abbreviations:

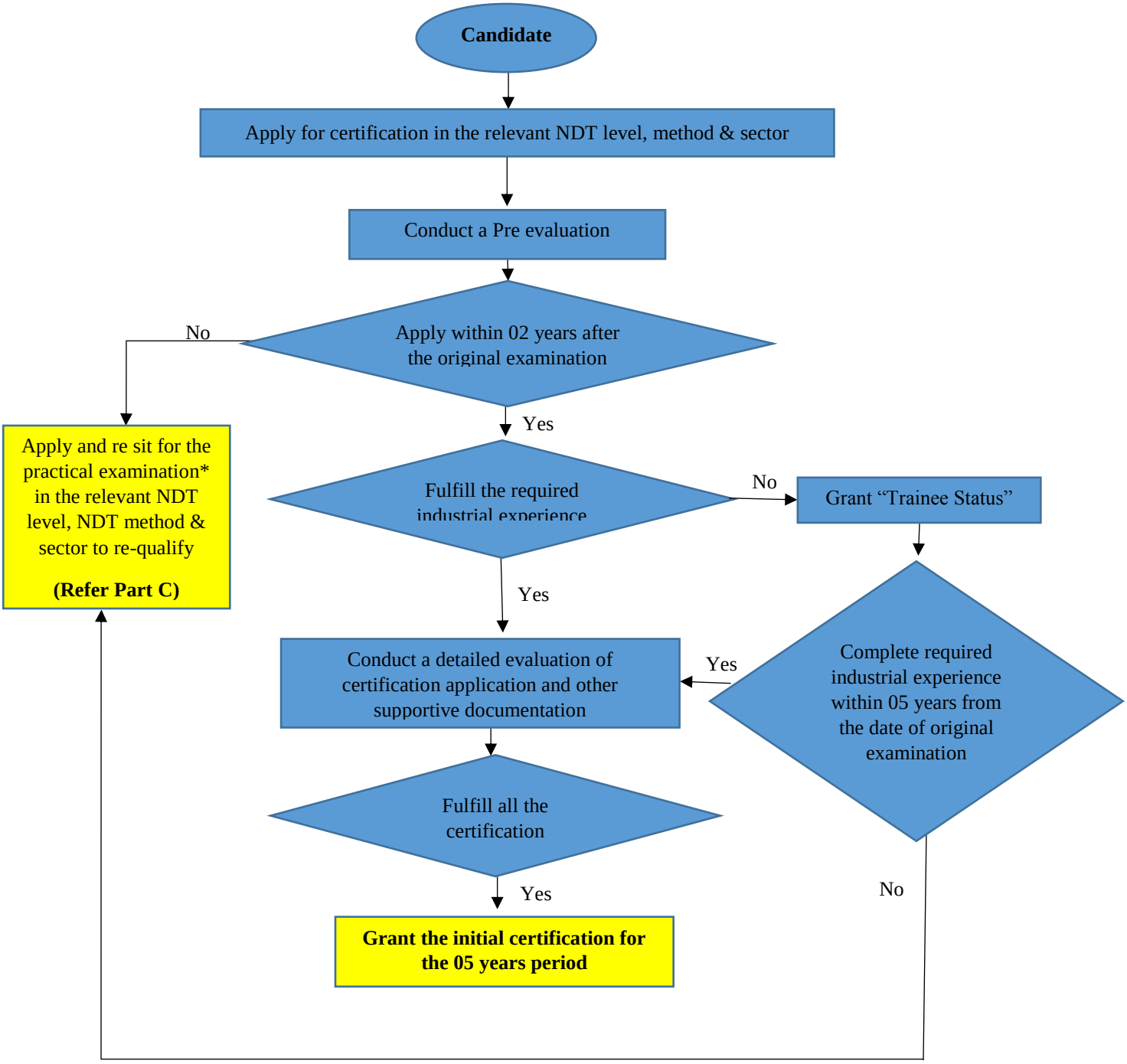
BW : But Welded (Pipe, Plate)
ET : Eddy Current Testing
GE : General Engineering
MS : Multi Sector
MT : Magnetic Particle Testing
N : Nozzle
UT : Ultrasonic Testing
VT : Visual Testing
WP : Wrought Products except Forgings
PI : Pre and In-service
PT : Liquid Penetrant Testing
RT-F : Radiographic Testing - Film
T : Tee

Note: [*1]Pending Scope Extension

PART A-Qualification Process

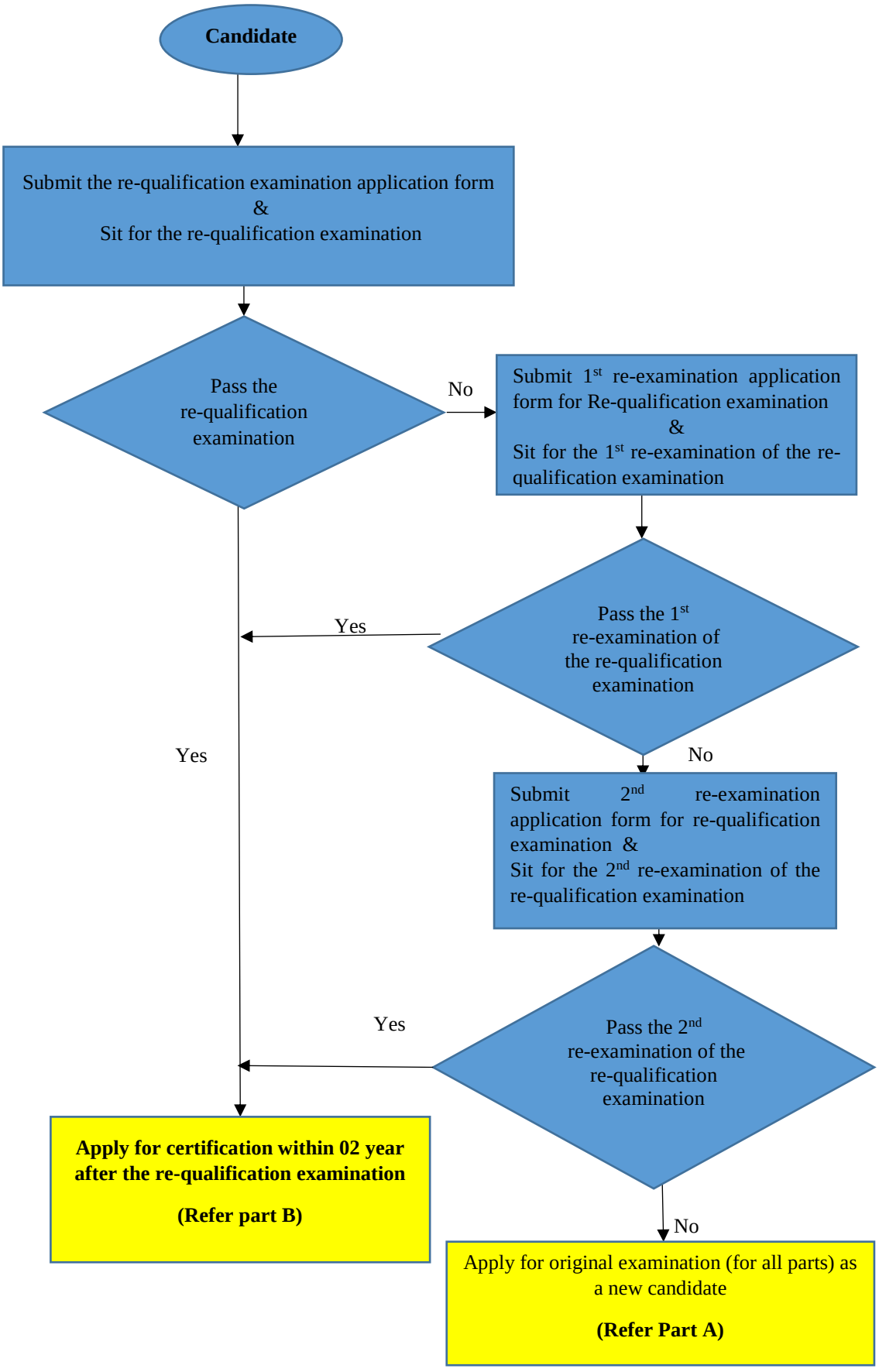


PART B-Certification Process



* Note: Level 2 practical examination is except for the drafting of instruction writing.

PART C-Re-Qualification Process



Method and Topic of the Lecture	Level 1	Level 2	Level 3
1. GENERAL KNOWLEDGE	**(04 HRS)** **1.1 INTRODUCTION –NDT** 1.1.1 Definitions 1.1.2 Characteristics of NDT as a technology and Reasons for using NDT 1.1.3 Description of Conventional NDT methods a) Visual testing b) Liquid penetrant testing c) Magnetic particle testing d) Radiographic testing e) Ultrasonic testing f) Eddy current testing g) Leak testing 1.1.4 Advantages and limitations in the common NDT methods. 1.1.5 Responsibilities of personnel certified to level 1, 2 and 3 personnel **1.2 INTRODUCTION -MATERIALS** 1.2.1 Properties of materials (metal and non-metal) 1.2.2 Properties of metals 1.2.3 Discontinuities and defects 1.2.4 Inherited defects 1.2.5 Primary processes and related defects a)Casting b) Welding c) Forging d) Rolling	**(10 HRS)** **1.1BASIC PRINCIPLES OF NDT** 1.1.1 Definitions, physical principle and methodology of applications of basic NDT methods: VT, PT, MT, RT, UT, ET, LT 1.1.2 Area of application of common NDT methods 1.1.3 Advantages and limitations of common NDT methods 1.1.4 Other NDT methods 1.1.5 Certification of NDT Personnel **1.2 INTRODUCTION - MATERIALS** 1.2.1 Structures of metals and alloys 1.2.2 Physical and mechanical properties of materials (metallic and non-metallic) 1.2.3 Discontinuities, defects and indications, 1.2.4 Inherited, processing and In-service discontinuities 1.2.5 Primary processes and inherited discontinuities	**(16 HRS)** **1.1 NDT, MATERIALS AND PROCESSES** 1.1 NDT methods- knowledge of at least 4 NDT methods at level 2 1.1.1 Scope and limitations: comparison of different NDT methods 1.1.2 Selection of methods 1.2 Technology of materials 1.2.1 Discontinuities and defects in materials. Classification according to location and morphology 1.2.2 Properties of materials 1.2.3 Nature of materials and solid state changes in materials 1.2.4 Phase Diagram and allotropy, ferrous metals 1.2.5 Non-ferrous metals and plastics 1.2.6 Nature of manufacturing 1.2.7 Casting process 1.2.8 Welding process 1.2.9 Rolling process 1.2.10 Forging process 1.2.11 Powder metallurgy 1.2.12 Machining fundamentals 1.2.13 miscellaneous processes 1.2,14 Mechanism of in-service defect formation (corrosion, wear, tear, fatigue crack,

	e) Heat treatment f) Machining g) Plating 1.2.6 In-service defects a) Overload b) Fatigue c) Corrosion d) Erosion e) Brittle fracture f) Others	1.2.6 Metallurgical processes and discontinuities derived from them 1.2.7 Materials in service and discontinuities formed during in-service **1.3 QUALITY AND STANDARDIZATION** 1.3.1 Importance of quality control and quality assurance 1.3.2 Definition of quality, quality control and standardization 1.3.3 Responsibility for quality 1.3.4 Quality control application of NDT 1.3.5 Quality manuals 1.3.6 Quality system	creep, hydrogen embrittlement, stress corrosion cracking, etc 1.2.13 Surface finishing **(06 HRS)** **1.2. QUALITY ASSURANCE AND STANDARDIZATION** 1.2.1 Quality assurance 1.2.1.1 Basic principles for the application of quality assurance 1.2.1.2 Organization of quality assurance, Quality manual, Quality control, Auditing ofQuality. 1.2.1.3 Management and control of quality assurance documentation, quality control of testing 1.2.1.4 Certification and accreditation of NDT facilities 1.2.1.5 Reports on testing, documentation systems 1.2.2 Standardization 1.2.2.1 Definition of standardization, principles for writing of standards 1.2.2.2 Codes, standards, specification procedures and instructions 1.2.2.3 Procedure Writing, i.e format, structure, and content of procedures 1.2.2.4 Procedure validation- 1.2.3 Reports and protocols **(04 HRS)**

			1.3 ORGANIZATION AND ADMINISTRATION OF NDT 1.3.1 Organization and administration of NDT 1.3.1.1 Safety: a) Implementation of industrial safety standards in facilities and equipment and in their operation b) Hazards of using toxic and inflammable materials c) Materials, accessories and equipment, for the protection of persons and facilities 1.3.1.2 Organization a) Organization structure of NDT Department or NDT organization b) Equipment for work under way; Logistic provisions c) Testing on production lines; Flow of materials; Work shifts d) Maintenance of equipment and facilities 1.3.1.3 Costs a) Investments in equipment b) Direct and indirect staff costs c) Calculation and analysis of costs and profitability 1.3.1.4 Equipment selection and facility design 1.3.1.5 Operating procedures and record keeping **(04 HRS)**

			1.4. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL 1.4.1 Training, Qualification and Certification of NDT personnel 1.4.1.1 National standards for the qualification and certification of personnel. 1.4.1.2 Regional and international recommendations, e.g ISO 9712 1.4.1.3 Organization of courses and training in NDT methods 1.4.1.4 Code of ethics **(10HRS)** **1.5. REVISION OF FOUR MAIN NDT METHODS**
2. PHYSICAL PRINCIPLES	**(06 HRS)** **2.1 Electricity** 2.1.1 Direct current a) amperage and voltage, b) Ohm's law and resistance, c) conductivity and resistivity 2.1.2 Alternating current a) amplitude and phase, b) impedance **2.2 Magnetism** 2.2.1 Magnetic theory a) induction and magnetic fields, b) magnetic permeability, c) iron magnetization 2.2.2 Induced magnetic flux	**(04HRS)** **2.1 Electricity** 2.1.1 Direct current a) amperage and voltage, b) Ohm's law and resistance, c) conductivity and resistivity 2.1.2 Alternating current a) amplitude and phase, b) impedance **2.2 Magnetism** 2.2.1 Magnetic data a) induction and magnetic fields, b) magnetic permeability, c) iron magnetization, d) B-H curve,	**(04 HRS)** **2.1 Phenomena of electromagnetic induction** 2.1.1 Field generated by a current 2.1.2 Field/induction relationship 2.1.3 Flux of induction vector 2.1.4 Electromotive force of induction 2.1.5 Self- inductance, coefficient of self- inductance 2.1.6 Mutual inductance, coefficient of mutual inductance, coupling coefficient **2.2 Impedance of a circuit in the presence of another circuit** 2.2.1 Representation of impedance plane

	a) Definition, b) lines of force and force fields, c) flux conservation, residual magnetism **2.3 Electromagnetism** 2.3.1 Magnetic field produced by a current 2.3.2 Current induced by a magnetic field; eddy current, inductance 2.3.3 Field created by eddy current, reactance **2.4 Eddy current distribution** 2.4.1 Plane conductors a) variation of amplitude and phase of current, b) depth of standard penetration, c) defect reaction according to position 2.4.2 Cylindrical bars a) Characteristic frequencies, b) variation of amplitude and phase of currents, c) depth of standard penetration, d) defect reaction according to position 2.4.3 Tubes a) Characteristic frequencies, b) variations of amplitude and phase, c) depth of standard penetration, d) defect reaction according to position	e) Hysteresis loop 2.2.2 Induced magnetic flux a) definition, b) lines of force and force fields, c) flux conservation, residual magnetism 2.2.3 Magnetic Ohm's law a) magnetomotive force, b) reluctance, c) magnetic circuits **2.3 Magnetic field produced by a current** 2.3.1 Biot and Savart law a) definition, b) practical rules, c) right hand rule 2.3.2 Ampere's law a) definition, b) applications (toroid, infinite coil, flat coil) **2.4 Electromagnetic induction law** 2.4.1 Lenz's law a) definition, b) auto induction factor, c) mutual induction factor, d) coupling factor 2.4.2 Induced currents a) in a short- circuit coil,	2.2.2 Effect of variation in fill factor 2.2.3 Normalized impedance plane 2.2.4 Effect of variation in frequency 2.2.5 Influence of a magnetic field **2.3 Electromagnetic wave propagation** 2.3.1 Basic laws 2.3.2 Application to a plane wave incident at a plane conductor- decreasing delay of fields and currents and phase 2.3.3 Definition of the standard penetration depth (d) 2.3.4 Expression of (d) in the specific case of plane 2.3.5 Definition of the similarity law **2.4 Eddy current distribution in test pieces** 2.4.1 Bars, simplifying hypothesis, similarity law, limit frequency, eddy currentdistribution (amplitude, phase), standard penetration depth 2.4.2 Tubes, simplifying hypothesis, similarity law, different expressions of limit frequency, eddy current distribution, standard penetration depth

		b) in a metallic mass, c) skin effect, d) field created by eddy current, e) reactance	2.4.3 Field applied to short test pieces, similarity law, simplifying hypothesis, limit frequency in simple cases, case of magnetic materials 2.4.4 Field applied to surfaces, complexity due to different parameters 2.4.5 Characterization of geometrical discontinuities, hypothesis of interrupted currents, point defects, extensive defects, multiple defects **2.5 Impedance diagrams for specific cases, feed through coils, bars, tubes, short test pieces in feed through coils, operating points, sensitivity**
3. INSTRUMENTATION	**(06 HRS)** **3.1 Principles and basic characteristics of eddy current probes** 3.1.1 Induction and reception functions 3.1.2 Absolute and differential measure 3.1.3 Types of probes **3.2 Reaction of different types of probes according to coil layout** 3.2.1 Reaction to small defects 3.2.2 Reaction to long defects 3.2.3 Reaction to continuous defects **3.3 Working principles of eddy current equipment**	**(12 HRS)** **3.1 Principles and basic characteristics of eddy current probes** 3.1.1 Induction and reception functions 3.1.2 Absolute and differential measurements 3.1.3 Types of probes **3.2 Eddy current distribution relative to coil position** 3.2.1 Field generated by non-load inductor coil	**(11 HRS)** **3.1 Principles and basic characteristics of eddy current probes** 3.1.1 Induction and reception functions 3.1.2 Absolute and differential measurements 3.1.3 Test coil arrangements, encircling coil, internal coil, surface coil, hybrid coil, coils-distance, double-differential coils, multi-differential coils

	3.3.1 Transmission 3.3.2 Reception 3.3.3 Data presentation **3.4 Adjustment of eddy current equipment** 3.4.1 Frequency 3.4.2 Energizing device 3.4.3 Balance 3.4.4 Phase rotation 3.4.5 Output filter 3.4.6 Gain **3.5 Different types of eddy current equipment** 3.5.1Monoparameter and monochannel equipment 3.5.2 Specialized equipment **3.6 Auxiliary devices** 3.6.1 Auxiliary devices for signal acquisition 3.6.2 Driving mechanism, saturating unit, demagnetizer 3.6.3 Equipment for signal storage, stripchart recorders and digital memories 3.6.4 System for automatic processing of signals	3.2.2 Eddy current path in a part according to its position relative to inductor coil 3.2.3 Distance influence on coupling in various shapes 3.2.4 Focusing methods **3.3 Reaction of different types of probes according to coil layout** 3.3.1 Reaction to small defects 3.3.2 Reaction to long defects 3.3.3 Reaction to continuous defects **3.4 Technology and practical characteristics of probes** 3.4.1 Design technology 3.4.2 Manufacturing technology 3.4.3 Electrical parameters 3.4.4 Maintenance **3.5 Main functions and adjustments of the equipment** 3.5.1 Oscillator 3.5.2 Energizing device 3.5.3 Measuring system 3.5.4 Balance 3.5.5 Amplifier and filter 3.5.6 Demodulator	3.1.4 Focusing means, magnetic circuits, coil arrangements **3.2 Use of probes** 3.2.1 Field from an empty short coil, divergence between practice and theory 3.2.2 Difference in coupling and current distribution resulting form different coi1 arrangements **3.3 Working principle of eddy current equipment** 3.3.1 Transmission 3.3.2 Reception 3.3.3 Data presentation **3.4 Main functions and adjustments of the equipment** 3.4.1 Oscillator 3.4.2 Energizing device 3.4.3 Measuring system 3.4.4 Balance 3.4.5 Amplifier and filter 3.4.6 Demodulator 3.4.7 Display (ellipse, time- base, impedance plane, vector point) 3.4.8 Phase rotation 3.4.9 Output filter **3.5 Classification of eddy current equipment**

		3.5.7 Display (ellipse, time-base, impedance plane, vector point) 3.5.8 Phase rotation 3.5.9 Output filter **3.6 Different types of eddy current equipment** 3.6.1 Monoparameter and monochannel equipment 3.6.2 Multiparameter and multichannel equipment **3.7 Auxiliary devices** 3.7.1 Auxiliary devices for signal acquisition 3.7.2 Driving mechanism, saturating unit, demagnetizer 3.7.3 Equipment for signal storage: stripchart recorders and digital memories 3.7.4 System for automatic processing of signals	3.5.1 One parameter equipment, specialized equipment, one way equipment 3.5.2 Multi-parameter equipment, two way equipment, multi-frequency equipment 3.5.3 Pulsed eddy current equipment **3.6 Auxi1lary devices** 3.6.1 Auxiliary devices for signal acquisition 3.6.2 Driving mechanism, saturating unit, demagnetizer 3.6.3 Equipment for signal storage, stripchart recorders and digital memories 3.6.4 System for automatic processing of signals
4. TESTING PROCEDURE	**(09 HRS)** **4.1 Influence of defect position and orientation** 4.1.1 Eddy current path 4.1.2 Penetration depth 4.1.3 Zone of probe action **4.2 Influence of material temperature** 4.2.1 Heating	**(12 HRS)** **4.1 Influence of defect position and orientation** 4.1.1 Eddy current path 4.1.2 Penetration depth 4.1.3 Zone of probe action **4.2 Influence of material temperature**	**(12 HRS)** **4.1 Influence of defect position and orientation** 4.1.1 Eddy current path 4.1.2 Penetration depth 4.1.3 Zone of probe action **4.2 Influence of material temperature** 4.2.1 Heating

	4.2.2 Deviations 4.2.3 Compensation **4.3 Influence of structure and geometry of tested parts (noise)** 4.3.1 Choice of test frequency 4.3.2 Phase discrimination 4.3.3 Filtering 4.3.4 Magnetic saturation **4.4 Coupling influence** 4.4.1 Vibrations 4.4.2 lift-off 4.4.3 Centering, fill factor 4.4.4 Sensitivity 4.4.5 Compensation **4.5 Reference standards used in eddy current testing** 4.5.1 Function of reference standards 4.5.2 Choice of reference standard 4.5.3 Fabrication and reproducibility of various types of reference standards **4.6 Inspection method** 4.6.1 Range of inspection 4.6.2 Recording of indications	4.2.1 Heating 4.2.2 Deviations 4.2.3 Compensation **4.3 Influence of structure and geometry of tested parts (noise)** 4.3.1 Choice of test frequency 4.3.2 Phase discrimination 4.3.3 Filtering 4.3.4 Magnetic saturation **4.4 Coupling influence** 4.4.1 Vibrations 4.4.2 Lift-off 4.4.3 Centering-fill factor 4.4.4 Sensitivity 4.4.5 Compensation **4.5 Influence of relative part/probe speed** 4.5.1 Testing frequencies according to speed 4.5.2 Bandwidths of apparatus according to testing speed **4.6 Reference standards used in eddy current testing** 4.6.1 Function of reference standards 4.6.2 Choice of reference standard	4.2.2 Deviations 4.2.3 Compensation **4.3 Influence of structure and geometry of tested parts (noise)** 4.3.1 Choice of test frequency 4.3.2 Phase discrimination 4.3.3 Filtering 4.3.4 Magnetic saturation **4.4 Coupling influence** 4.4.1 Vibrations 4.4.2 Lift-off 4.4.3 Centering, fill factor 4.4.4 Sensitivity 4.4.5 Compensation **4.5 Influence of relative part/probe speed** 4.5.1 Testing frequencies according to speed 4.5.2 Bandwidths of apparatus according to testing speed **4.6 Reference standards used in eddy current testing** 4.6.1 Function of reference standards 4.6.2 Choice of reference standard 4.6.3 Fabrication and reproducibility of various types of reference standards **4.7 Inspection method** 4.7.1 Range of inspection

		4.6.3 Fabrication and reproducibility of various types of reference standards **4.7 Inspection method** 4.7.1 Range of inspection 4.7.2 Recording of indications 4.7.3 Analysis and interpretation of results **4.8 Preparation of written instructions for level 1**	4.7.2 Recording of indications 4.7.3 Analysis and interpretation of results
5. APPLICATIONS	**(03 HRS)** **5.1 Measurement of product composition** 5.1.1 Measuring by electrical conductivity **5.2 Thickness measurement** 5.2.1 Thickness of a product 5.2.2 Thickness of coating **5.3 Geometric defect characterization** 5.3.1 Hypothesis of interrupted currents **5.4 Main types of discontinuities detected by eddy current testing** 5.4.1 Discontinuities arising from production 5.4.2 Discontinuities arising during hot or cold processing 5.4.3 Discontinuities arising during service **5.5 Defect detection** 5.5.1 Absolute measurement 5.5.2 Differential measurement	**(11 HRS)** **5.1 Geometric defect characterization** 5.1.1 Hypothesis of interrupted currents 5.1.2 Case of point defects 5.1.3 Case of large defects 5.1.4 Case of multiple defects **5.2 Coil with a long conductive product (bar or tube)** 5.2.1 Impedance diagram 5.2.2 Influence of various parameters 5.2.3 Ferromagnetic products **5.3 Use of impedance diagrams** 5.3.1 Definition of operating point	**(11 HRS)** **5.1 Electromagnetic properties of materials** 5.1.1 Electrical conductivity; effects of chemical composition, temperature, grain size and structure 5.1.2 Magnetic permeability: dia-, para- and ferromagnetic, hysteresis loop, Rayleigh area, saturation, Weiss area, Curie point, effects of chemical composition, grain size, structure **5.2 Anomalies related to manufacture and use of products** 5.2.1 Related to the manufacture of cast, extruded or rolled products

		5.3.2 Choice of operating point according to sensitivity of parameter splitting **5.4 Electromagnetic properties of materials** 5.4.1 Electrical conductivity 5.4.2 Chemical analysis, temperature, grain size, texture influence, structure 5.4.3 Magnetic permeabi1ity: chemical analysis, structure, grain size and texture influence **5.5 Main types of discontinuities detected by eddy current testing** 5.5.1 Discontinuities arising from production 5.5.2 Discontinuities arising during hot or cold processing 5.5.3 Discontinuities arising during service **5.6 Thickness measurement** 5.6.1 Thickness of a product 5.6.2 Thickness of coatings **5.7 Measurement of product composition** 5.7.1 Measuring by electrical conductivity	5.2.2 Related to service, creep, fatigue, corrosion **5.3 Defect detection** 5.3.1 Absolute measurement 5.3.2 Differential measurement **5.4 Thickness measurement** 5.4.1 Thickness of a product 5.4.2 Thickness of coating **5.5 Measurement of product composition** 5.5.1 Measuring by electrical conductivity **5.6 Recent developments in eddy current testing** 5.6.1 Multifrequency eddy current testing, principles, applications 5.6.2 Pulsed eddy current testing, principles, applications 5.6.3 Electromagnetic transducers, principles of conversion, advantages 5.6.4 Arrays captors **5.7 Problems encountered in eddy current inspection** 5.7.1 Position and orientation of defects, eddy current paths, penetration depth 5.7.2 Structure and geometry for the test pieces, noise, frequency, phase discrimination

		5.7.2 Measuring by magnetic permeability **5.8 Inspection of welds** 5.8.1 Characteristic probes and frequencies 5.8.2 Defect reaction according to position and weld shape **5.9 Multifrequency eddy current testing** 5.9.1 Principles 5.9.2 Equipment 5.9.3 Applications	5.7.3 Lift- off, vibrations, centering, sensitivity 5.7.4 Coil-specimen relative speed, test frequency as a function of speed 5.7.5 Temperature, overheating, drift, compensation 5.7.6 Equipment, repeatability of measurement, deviation of equipment characteristics, calibration
6. CODES, STANDARDS, PROCEDURES	**(01 HRS)** **6.1 Codes and standards related to Eddy current testing** **6.2 Interpretation of written instructions for application of the test**	**(01 HRS)** **6.1 Codes and standards related to Eddy current testing** **6.2 Interpretation of procedures for the application of the test**	**(04 HRS)** **6.1 Specifications of the examination, function of design engineering, design and building codes, ASME code.** **6.2 Standards** 5.2.1 Specific standards for tests (ASME, ISO) 5.2.2 Interpretation of specifications, codes and standards **5.3 Test procedures** 5.3.1 Formulation of test procedures 5.3.2 General and specific procedures **5.4 Procedure writing**

7. RECORDING AND EVALUATION OF RESULTS	**(02HRS)** **7.1 Written instructions** **7.2 Report preparation**	**-(03 HRS)** **7.1 Codes and standards which apply to eddy current testing** **7.2 Standards for equipment characteristics and verification** **7.3 Specifications and procedures which apply to the method** **7.4 Inspection techniques and their use** **7.5 Inspection reports**	**(08 HRS)** **6.1 Codes and standards which apply to eddy current testing** **6.2 Standards for equipment characteristics and verification** **6.3 Specifications and procedures which apply to the method** **6.4 Inspection techniques and their use** **6.5 Inspection reports**
8.PRACTICAL	**(23 HRS)** **8.1 Practical** 8.1.1Familiarization of the functions of the various controls which are used to adjust the eddy current system. (Setting up the Instrument, Selection of Frequencies for Tube Inspection, Selection of Probe Size, Calibrations,) 8.1.2Demonstrate the reaction of the different types of coil to defects of various geometries. 8.1.3Electrical conductivity measurements 8.1.4 Thickness measurements of a product	**(25 HRS)** **8.1 Instruction Writing** **8.2 Practical** 8.2.1 Same as for Level I + Interpretation, evaluation, and preparation of test reports 8.2.2 Influence of coupling on the eddy current indications 8.2.3Influence of probe speed relative to the part on the eddy current results. 8.2.4 Magnetic comparator 8.2.5 weld inspection with a representative standard 8.2.6 Application of multi frequency eddy current test equipment	**N/A**

	8.1.5 Thickness measurements of a coating 8.1.6 Perform Eddy current testing 8.1.7Absolute and differential measurements in eddy current testing. 8.1.8 Carry out an eddy current inspection following written instructions. 8.1.9 Identification of relevant and non-relevant indications 8.1.10Training to follow guidelines in codes and standards		
TOTAL	54HRS	78HRS	90 HRS

Table 2 — Minimum training requirements

NDT method		Level 1 h	Level 2 h	Level 3 h
AT		40	64	48
ET		40	48	48
LT	B — Pressure method	24	32	32
	C — Tracer gas method	24	40	40
MT		16	24	32
PT		16	24	24
ST		16	24	20
TT		40	80	40
RT		40	80	40
UT		40	80	40
VT		16	24	24
NOTE For RT, training hours do not include radiation safety training.				

Method and Topic of the Lecture	Level 1	Level 2	Level 3
MT			
1. GENERAL KNOWLEDGE	**(04 HRS)** **1.1 INTRODUCTION –NDT** 1.1.1 Definitions 1.1.2 Characteristics of NDT as a technology and Reasons for using NDT 1.1.3 Conventional NDT methods a) Visual testing b) Liquid penetrant testing c) Magnetic particle testing d) Radiographic testing e) Ultrasonic testing f) Eddy current testing g) Leak testing 1.1.4 Advantages and limitations in the common NDT methods. 1.1.5 Responsibilities of personnel certified to level 1, 2 and 3 personnel **1.2 INTRODUCTION -MATERIALS** 1.2.1 Properties of materials (metal and non-metal) 1.2.2 Properties of metals 1.2.3 Discontinuities and defects 1.2.4 Primary processes and related defects a)Casting b) Welding c) Forging d) Rolling e) Heat treatment f) Machining g) Plating	**(06 HRS)** **1.1BASIC PRINCIPLES OF NDT** 1.1.1 Definitions, physical principle and methodology of applications of basic NDT methods: VT, PT, MT, RT, UT, ET, LT 1.1.2 Area of application of common NDT methods 1.1.3 Advantages and limitations of common NDT methods 1.1.4 Other in NDT methods 1.1.5 Certification of NDT Personnel 1.1.6 Importance of quality control and quality assurance **1.2 INTRODUCTION - MATERIALS** 1.2.1 Structures of metals and alloys 1.2.2 Physical and mechanical properties of materials (metallic and non-metallic) 1.2.3 Discontinuities, defects and indications, 1.2.4 Inherited, processing and In-service discontinuities 1.2.5 Primary processes and inherited discontinuities 1.2.6 Metallurgical processes and discontinuities derived for them	**(16 HRS)** **1.1 NDT, MATERIALS AND PROCESSES** 1.1 NDT methods- knowledge of at least 4 NDT methods at level 2 1.1.1 Scope and limitations: comparison of different NDT methods 1.1.2 Selection of methods 1.2 Technology of materials 1.2.1 Discontinuities and defects in materials. Classification according to location and morphology 1.2.2 Properties of materials 1.2.3 Nature of materials and solid state changes in materials 1.2.4 Phase Diagram and allotropy, ferrous metals 1.2.5 Non-ferrous metals and plastics 1.2.6 Nature of manufacturing 1.2.7 Casting process 1.2.8 Welding process 1.2.9 Rolling process 1.2.10 Forging process 1.2.11 Powder metallurgy 1.2.12 Machining fundamentals 1.2.13 miscellaneous processes 1.2,14 Mechanism of in-service defect formation (corrosion, wear, tear, fatigue crack,

	1.2.5 In-service defects a) Overload b) Fatigue c) Corrosion d) Erosion e) Brittle fracture f) Others	1.2.7 Materials in service and discontinuities formed during in-service	creep, hydrogen embrittlement, stress corrosion cracking, etc 1.2.13 Surface finishing **(06 HRS)** **1.2. QUALITY ASSURANCE AND STANDARDIZATION** 1.2.1 Quality assurance 1.2.1.1 Basic principles for the application of quality assurance 1.2.1.2 Organization of quality assurance, Quality manual, Quality control, Auditing of Quality. 1.2.1.3 Management and control of quality assurance documentation, quality control of testing 1.2.1.4 Certification and accreditation of NDT facilities 1.2.1.5 Reports on testing, documentation systems 1.2.2 Standardization 1.2.2.1 Definition of standardization, principles for writing of standards 1.2.2.2 Codes, standards, specification procedures and instructions 1.2.2.3 Procedure Writing, i.e format, structure, and content of procedures 1.2.2.4 Procedure validation- 1.2.3 Reports and protocols **(04 HRS)**

			1.3 ORGANIZATION AND ADMINISTRATION OF NDT 1.3.1 Organization and administration of NDT 1.3.1.1 Safety: a) Implementation of industrial safety standards in facilities and equipment and in their operation b) Hazards of using toxic and inflammable materials c) Materials, accessories and equipment, for the protection of persons and facilities 3.1.2 Organization a) Organization structure of NDT Department or NDT organization b) Equipment for work under way; Logistic provisions c) Testing on production lines; Flow of materials; Work shifts d) Maintenance of equipment and facilities 1.3.1.3 Costs a) Investments in equipment b) Direct and indirect staff costs c) Calculation and analysis of costs and profitability 1.3.1.4 Equipment selection and facility design 1.3.1.5 Operating procedures and record keeping **(04 HRS)**

			1.4. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL 1.4.1 Training, Qualification and Certification of NDT personnel 1.4.1.1 National standards for the qualification and certification of personnel. 1.4.1.2 Regional and international recommendations, e.g ISO 9712 1.4.1.3 Organization of courses and training in NDT methods 1.4.1.4 Code of ethics **(10HRS)** **1.5. REVISION OF FOUR MAIN NDT METHODS**

2. PHYSICAL PRINCIPLES AND FUNDAMENTAL OF THE MAGNETIC PARTICLE	**(03 HRS)** **2.1 Electricity (General principles)** 2.1.1 Current, 2.1.2 Voltage, 2.1.3 Resistance 2.1.4 Alternating current, 2.1.5 Direct current **2.2 Magnetism (general principles)** 2.2.1 Magnetic poles; permanent magnets; temporary magnets 2.2.2 Permeability 2.2.3 Ferromagnetic, paramagnetic and diamagnetic materials 2.2.4 Magnetic fields; lines of force; magnetic fields around the conductor 2.2.5 Solenoid, electromagnet, 2.2.6 Magnetic flux, 2.2.7 Magnetization force 2.2.8 Reluctance 2.2.9 Hysteresis **2.3 Visible and ultraviolet light** **2.4 Method of testing by magnetic particles**	**(03 HRS)** **2.1 Electricity** 2.1.1 Current, voltage and resistance; alternating current; direct current **2.2 Magnetism; magnetic poles; permanent magnets; temporary magnets** 2.2.1 Ferro-,para-,and dia- magnetic materials 2.2.2 Magnetic fields; lines of force; magnetic field around a conductor; solenoid; electromagnet; magnetic flux; magnetization force; reluctance; hysteresis **2.3 Magnetic field characteristics; remanence; permeability; saturation; normal and tangential components of the magnetic field** **2.4 Terminology and abbreviations** **2.5 Electromagnetic waves** **2.6 Visible and ultraviolet light**	**(02 HRS)** **2.1 Magnetism** 2.1.1 Theory and characteristics of the magnetic fields 2.1.2 Demagnetizing effect 2.1.3 Separation of the magnetic field **2.2 Magnetic induction in materials** 2.2.1 Permeability in ferromagnetic and non-ferromagnetic materials 2.2.2 Film effect **2.3 Magnetic fields** 2.3.1 Generation of magnetic fields 2.3.2 Basis for the calculation on of magnetization systems **2.4 Measurement of** 2.4.1 Magnetic fields 2.4.2 Electromagnetic fields **2.5 Electromagnetic radiation** 2.5.1 Visible light 2.5.2 Field radiation 2.5.3 Physical concepts, measurements and equipment 2.5.4 Conditions for visual observation 2.5.5 Luminance thresholds 2.5.6 Visual acuity
3. METHODS AND TECHNIQUES	**(02 HRS)** **3.3 Inspection techniques** 3.3.1 Remnant fields 3.3.2 Continuous field 3.3.3 Wet method 3.3.4 Dry method	**(03 HRS)** **3.1 Methods of magnetization** 3.1.1 Longitudinal 3.1.2 Circular **3.2 Magnetization techniques**	**(03 HRS)** 3.1 Magnetization **3.1.1 Magnetization methods** 3.1.2 Magnetization techniques a) Types of magnetic field application b) Intensity and type of current

	3.3.5 Verification of magnetic fields 3.3.6 Retentivity and coercive force **3.4 Demagnetization** 3.4.1 Reasons for requiring demagnetization 3.4.2 Demagnetization techniques and verification of remanent fields	3.2.1 Permanent magnets 3.2.2 Electromagnets **3.2.3 Coils** 3.2.4 By passage of current 3.2.5 By induction **3.3 Work methods** 3.3.1 Remnant field 3.3.2 Continuous field 3.3.3 Dry method 3.3.4 Wet method **3.4 Testing techniques** 3.4.1 For work pieces of differing alloy or, shape and condition 3.4.2 With various types of current 3.4.3 Field direction for some specific cases 3.4.4 Appropriate field intensity 3.4.5 Test sequences 3.4.6 Safety precautions **3.5 Miscellaneous field practices** 3.5.1 Preparation of the wet and dry suspension for coloured and fluorescent particles 3.5.2 Techniques for checking field sensitivity a) field indicators for calibration test pieces b) work pieces for evaluating the sensitivity of the test c) work pieces for evaluating magnetic particles	c) Combined magnetization d) Individual cases e) Incremental permeability **3.2 Modes of operation** 3.2.1 Continuous field, conditions for application of the inspection medium. 3.2.2 Remanent field **3.3 Indicating medium** 3.3.1 Physical and chemical conditions necessary for the particles and suspension vehicles, wet and dry methods, fluorescent particles. 3.3.2 Conditions for applying the indicating medium **3.4 Evaluation** 3.4.1 Verification of the sensitivity of the test. Determination of the applicability of the various field indicators 3.4.2 Verification of visibility conditions and requirements for existing fluorescence 3.4.3 Correlation between defectology, the test findings and the technique applied **3.5 Demagnetization** 3.5.1 Reasons for demagnetizing 3.5.2 Evaluation of remnant magnetic fields 3.5.3 Requirements and conditions for demagnetization in accordance with the

		3.5.3 Reasons for demagnetization a) operating conditions b) testing the effectiveness of demagnetization	technique of the test use and the material examined.
4. TEST EQUIPMENT AND MATERIALS, ACCESSORIES	**(01 HRS)** **4.1 Knowledge of equipment:** 4.1.1 Permanent magnets 4.1.2 Magnetic yokes 4.1.3 Portable and stationary equipment 4.1.4 Types of current 4.1.5 Test current capacity 4.1.6 Demagnetization equipment **4.2 Conditions of use:** 4.2.1 Equipment operation 4.2.2 Equipment maintenance 4.2.3 Safety **4.3 Accessories** 4.3.1 Contact points 4.3.2 Vessels for checking inspection baths 4.3.3 Field indicator (Berthold test piece) 4.3.4 Calibration test pieces (JIS, ASTM, EN, MIL) 4.3.5 Magnetic field measurement equipment 4.3.6 Ultraviolet lamps 4.3.7 Colored and fluorescent powders 4.3.8 Color for increasing contrast	**(01 HRS)** 4**.1 Knowledge of equipment** **Permanent magnets; magnetic yoke; portable and stationary equipment; types of current and concepts of testing capacity; demagnetization equipment; maintenance and use of equipment** **4.2 Accessories** 4.2.1 Contact points; vessels for checking bath concentration; 4.2.2field indicators (Berthold test pieces); 4.2.3 Calibration pieces (JIS,ASTM,EN,MIL); 4.2.4 magnetic field measurement equipment (Gaussmeter); 4.2.5 ultraviolet lamps; 4.2.6 colored and fluorescent powders; color for increasing contrast; morphology of the particles **4.3 Selection of equipment appropriate to the nature of the test**	**(03 HRS)** **4.1 Equipment** 4.1.1 Selection for purchase 4.1.2 Conditions of use and maintenance of equipment for magnetization and demagnetization, portable, permanently installed or automated 4.1.3 Design basis of systems for testing **4.2 Accessories** 4.2.1 Design, selection and use of accessories for various testing techniques 4.2.2 Field indicators a) Analysis and comparison of the various field indicators (Berthold, ASME, BS, etc.) b) Method of application and evaluation of application 4.2.3 Instruments for magnetic field measurement, use of the Gaussmeter 4.2.4 Various types of field radiation lamps and UV meters **4.3 Methods of indication** 4.3.1 Magnetizable particles a) Chemical and physical characteristics b) Morphology and dimensions

		4.4 Special equipment : Portable equipment; stationary installations; automated equipment	c) Various types: coloured and fluorescent 4.3.2 Suspension vehicles for tests by wet methods 4.3.3 Preparation and evaluation of indication media for test by wet and dry methods **4.4 AC and DC demagnetization equipment.** Demagnetization equipment based on the oscillatory discharge of condensers.
5. CODES, STANDARDS, PROCEDURES	**(02 HRS)** **5.1 Interpretation of written instructions for application of tests by different techniques** **5.2 Wet suspension of colored and fluorescent particles** 5.2.1 Preparation 5.2.2 Standards **5.3 Working with magnetic field** 5.3.1 Magnetic field test 5.3.2 Measurement of magnetic field 5.3.3 Demagnetization of work pieces **5.4 Codes, standards, specifications and procedures** 5.4.1 General knowledge of codes and standards 5.4.2 General knowledge of specifications and procedures	**(02 HRS)** **5.1 Interpretation of procedures for the application of tests using various techniques** **5.2 Composition of test procedures including instructions for various methods and techniques for use with work pieces of various materials and shapes, selection of equipment, field detection, intensity, type of current, selection of inspection medium, types of particles, sequence of testing, demagnetization** **5.3 Standards** 5.3.1 Qualification and certification of personnel	**(09 HRS)** **5.1 Specifications of the examination, function of design engineering, design and building codes, ASME code.** **5.2 Standards** 5.2.1 Specific standards for tests with magnetic particles (ASTM, JIS, BS, DIN) 5.2.2 Interpretation of specifications, codes and standards **5.3 Test procedures** 5.3.1 Formulation of test procedures 5.3.2 General and specific procedures **5.4 Procedure writing**

		5.3.2 Internal specifications and corresponding standards 5.3.3 Codes and standards	
6. PRESENTATION AND RECORDING OF RESULTS	**(01 HRS)** **6.1 Presentation of results on test forms** **6.2 Recording of indications:** 6.2.1 To locate and identify them with reference to the test piece 6.2.2 By photography **6.3 Recognition of findings** 6.3.1 Indications of defects 6.3.2 Spurious (false) indications	**(01 HRS)** **6.1 Preparation of reports on the testing** **6.2 Preparation and completion of the report form** **6.3 Documentation of the findings** a) to locate the indication within the component b) by the use of sketching and photography c) knowledge of documentation systems d) management and control of complete documentation	**(02 HRS)** **6.1 Preparation of reports of the test** **6.2 Preparation and completion of the report form** **6.3 Documentation of the findings:** a) to locate the indication within the component b) knowledge of documentation systems c) management and control of complete documentation

7. INTERPRETATION OF RESULTS AND LIMITATION OF THE METHOD		**(01 HRS)** **7.1 Presentation of results** **7.2 Interpretation of findings with reference to the manufacturing process:** a) evaluation of results according to the criteria of the procedure and specifications; b) additional possibilities for making the results more conclusive **7.3 Sensitivity and limitations** **7.4 Applications of magnetic testing and other methods of testing for surface and subsurface flaws** **7.5 Safety, implementation of industrial safety standards in facilities and equipment and in their operation; hazards of using toxic and inflammable materials; materials,** **equipment and accessories for the protection of persons and facilities** **7.6 Instruction writing**	**(02 HRS)** **7.1 Presentation of results** **7.2 Thresholds of detection** a) evaluation of results according to the criteria of the procedure and specifications b) additional possibilities for making the results more conclusive **7.3 Interpretation of findings with reference to the manufacturing process** **7.4 Applications of magnetic particle testing and other methods of testing for surface and subsurface flaws** **7.5 Procedure writing**
8. PRACTICAL	**8.1 Practical (11 HRS)** 8.1.1 Observe magnetism, residual magnetism, de-magnetization and fluorescence	**(13 HRS)** **8.1 Instruction Writing** **8.2 Practical** 8.2.1 Same as Level-I + Interpretation, evaluation ,recording	**N/A**

	8.1.2 Handling magnetizing equipment and materials 8.1.3 Carry out Magnetic particle testing 8.1.4 Identifying relevant and non-relevant indications 8.1.5 Training to follow guidelines in codes and standards	of test results and preparation of test reports 8.2.2 Identification of suitable techniques for various test pieces 8.2.3 Training to follow guidelines in codes and standards	
TOTAL	24 HRS	30 HRS	60 HRS

Table 2 — Minimum training requirements

NDT method		Level 1 h	Level 2 h	Level 3 h
AT		40	64	48
ET		40	48	48
LT	B — Pressure method	24	32	32
	C — Tracer gas method	24	40	40
MT		16	24	32
PT		16	24	24
ST		16	24	20
TT		40	80	40
RT		40	80	40
UT		40	80	40
VT		16	24	24
NOTE For RT, training hours do not include radiation safety training.				

Method and Topic of the Lecture	Level 1	Level 2	Level 3
PT			
1. GENERAL KNOWLEDGE	**(04 HRS)** **1.1 INTRODUCTION –NDT** 1.1.1 Definitions 1.1.2 Characteristics of NDT as a technology and reasons for using NDT 1.1.3 Conventional NDT methods a) Visual testing b) Liquid penetrant testing c) Magnetic particle testing d) Radiographic testing e) Ultrasonic testing f) Eddy current testing g) Leak testing 1.1.4 Advantages and limitations in the common NDT methods. 1.1.5 Responsibilities of personnel certified to level 1, 2 and 3 personnel **1.2 INTRODUCTION -MATERIALS** 1.2.1 Properties of materials (metal and non-metal) 1.2.2 Properties of metals 1.2.3 Discontinuities and defects 1.2.4 Primary processes and related defects a)Casting b) Welding c) Forging	**(06 HRS)** **1.1BASIC PRINCIPLES OF NDT** 1.1.1 Definitions, physical principle and methodology of applications of basic NDT methods: VT, PT, MT, RT, UT, ET, LT 1.1.2 Area of application of common NDT methods 1.1.3 Advantages and limitations of common NDT methods 1.1.4 Other in NDT methods 1.1.5 Certification of NDT Personnel 1.1.6 Importance of quality control and quality assurance **1.2 INTRODUCTION - MATERIALS** 1.2.1 Structures of metals and alloys 1.2.2 Physical and mechanical properties of materials (metallic and non-metallic) 1.2.3 Discontinuities, defects and indications, 1.2.4 Inherited, processing and In-service discontinuities 1.2.5 Primary processes and inherited discontinuities	**(16 HRS)** **1.1 NDT, MATERIALS AND PROCESSES** 1.1 NDT methods- knowledge of at least 4 NDT methods at level 2 1.1.1 Scope and limitations: comparison of different NDT methods 1.1.2 Selection of methods 1.2 Technology of materials 1.2.1 Discontinuities and defects in materials. Classification according to location and morphology 1.2.2 Properties of materials 1.2.3 Nature of materials and solid state changes in materials 1.2.4 Phase Diagram and allotropy, ferrous metals 1.2.5 Non-ferrous metals and plastics 1.2.6 Nature of manufacturing 1.2.7 Casting process 1.2.8 Welding process 1.2.9 Rolling process 1.2.10 Forging process 1.2.11 Powder metallurgy 1.2.12 Machining fundamentals 1.2.13 miscellaneous processes

	d) Rolling e) Heat treatment f) Machining g) Plating 1.2.5 In-service defects a) Overload b) Fatigue c) Corrosion d) Erosion e) Brittle fracture f) Others	1.2.6 Metallurgical processes and discontinuities derived for them 1.2.7 Materials in service and discontinuities formed during in-service	1.2,14 Mechanism of in-service defect formation (corrosion, wear, tear, fatigue crack, creep, hydrogen embrittlement, stress corrosion cracking, etc 1.2.13 Surface finishing **(06 HRS)** **1.2. QUALITY ASSURANCE AND STANDARDIZATION** 1.2.1 Quality assurance 1.2.1.1 Basic principles for the application of quality assurance 1.2.1.2 Organization of quality assurance, Quality manual, Quality control, Auditing of Quality. 1.2.1.3 Management and control of quality assurance documentation, quality control of testing 1.2.1.4 Certification and accreditation of NDT facilities 1.2.1.5 Reports on testing, documentation systems 1.2.2 Standardization 1.2.2.1 Definition of standardization, principles for writing of standards 1.2.2.2 Codes, standards, specification procedures and instructions

			1.2.2.3 Procedure Writing, i.e format, structure, and content of procedures 1.2.2.4 Procedure validation- 1.2.3 Reports and protocols **(04 HRS)** **1.3 ORGANIZATION AND ADMINISTRATION OF NDT** 1.3.1 Organization and administration of NDT 1.3.1.1 Safety: a) Implementation of industrial safety standards in facilities and equipment and in their operation b) Hazards of using toxic and inflammable materials c) Materials, accessories and equipment, for the protection of persons and facilities 3.1.2 Organization a) Organization structure of NDT Department or NDT organization b) Equipment for work under way; Logistic provisions c) Testing on production lines; Flow of materials; Work shifts d) Maintenance of equipment and facilities 1.3.1.3 Costs a) Investments in equipment b) Direct and indirect staff costs

			c) Calculation and analysis of costs and profitability 1.3.1.4 Equipment selection and facility design 1.3.1.5 Operating procedures and record keeping **(04 HRS)** **1.4. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL** 1.4.1 Training, Qualification and Certification of NDT personnel 1.4.1.1 National standards for the qualification and certification of personnel. 1.4.1.2 Regional and international recommendations, e.g ISO 9712 1.4.1.3 Organization of courses and training in NDT methods 1.4.1.4 Code of ethics **(10HRS)** **1.5. REVISION OF FOUR MAIN NDT METHODS**
2. PHYSICAL PRINCIPLES OF THE TEST	**(03 HRS)** **2.1 Description of the method** **2.2 Properties of penetrating liquids** 2.2.1 Wettability (expansion of the drop) 2.2.2 Penetration 2.2.3 Bleeding	**(03 HRS)** **2.1 General description of the method** **2.2 Properties of liquid penetrants** 2.2.1 Viscosity, surface tension, angle of contact between 1iquid and solid, capillarity	**(02 HRS)** **2.1 Review of physical, chemical and physico-chemical principles for applying themethod. Liquid- solid interface phenomena**

	2.2.4 Influence of the state of the surface, contamination and temperature **2.3 Concepts of solutions and dispersions** 2.3.1 Solvents 2.3.2 Dispersive agents 2.3.3 Emulsifiers **2.4 Concepts relating to the mechanism of development** 2.4.1 Powder granulometry 2.4.2 Suspension **2.5 Basic concepts relating to colour and fluorescence** 2.5.1 Dyes 2.5.2 Fluorescent pigments 2.5.3 UV and light radiation (black light) **2.6 Composition of oily and non-oily penetrating liquids** **2.7 Composition and/or properties of removers** 2.7.1 Organic solvents 2.7.2 Emulsifiers **2.8 Composition and state of developers** 2.8.1 Dry developers 2.8.2 Wet developers	2.2.2 Behavior of 1iquid penetrants, wettability, penetrability, washability, retention and bleeding 2.2.3 Influence of the surface state of the sample, contamination and temperature **2.3 Solutions and dispersions, solvents and dispersive agents** 2.3.1 Lipophi1ic and hydrophi1ic emulsifiers **2.4 Mechanism of development** 2.4.1 Granulometry of powders 2.4.2 Types and phenomena of fine powder aggregation 2.4.3 Suspension of powders in 1iquids **2.5 Luminous and ultraviolet spectrum** 2.5.1 Color and fluorescence 2.5.2 Colors 2.5.3 Absorption of 1ight 2.5.4 Beer’s law 2.5.5 Fluorescent pigments **2.6 Basic formulation of penetrating liquids with oily and non-oily base** 2.6.1 Additives and conditioners **2.7 Removers used in the process** 2.7.1 Basic formulations and properties 2.7.2 Emulsifiers	**2.2 Solutions and dispersions, solvents and dispersing agents, lipophilic and hydrophilic emulsifiers** **2.3 Physicochemical mechanisms determining penetration, emulsification and developing** **2.4 General spectrum of electromagnetic radiation, luminaries spectrum, ultraviolet and infra- red radiation, wood radiation (black light), measurement and units** **2.5 Color and fluorescence, light absorption phenomena, Beer's law, absorption spectrometry , fluorescent emission spectra** **2.5 Mechanism of vision, conditions for visual observations, perception of light, colourand contrast, systems of weighing units and thresholds**

		2.7.3 Lipophi1ic and hydrophi1ic agents **2.8 Composition and state of developers** 2.8.1 Granulometry 2.8.2 Developers in the dry state and in liquid suspension	
3. PROCESSING	**(02 HRS)** **3.1 Preparation of the specimen** 3.1.1 Treatment 3.1.2 Identification 3.1.3 Temperature **3.2 Cleaning prior to inspection** 3.2.1 Solvents 3.2.2 Types and techniques of use 3.2.3 Detergent solutions 3.2.4 Chemical action solutions (acids, alkalis, removers) 3.2.5 Inhibition and rinsing 3.2.6 Use of ultrasonic agitation 3.2.7 Mechanical media, brushing, grinding, sandblasting, etc. 3.2.8 Conditions and limitations on their use **3.3 Drying** 3.3.1 Drying requirements 3.3.2 Cold and hot air 3.3.3 Temperature and time	**(03 HRS)** **3.1 Preparation of the work piece, treatment, identification and protection of the areas not to be examined** **3.2 Cleaning prior to inspection** 3.2.1 Various techniques applicable a) Solvents b) Vapour degreasing c) Detergent solutions d) Solutions having a chemical action (acid and alkali removers, etc.) e) Ultrasonic cleaning f) Mechanical means (grinding, sandblasting, brushing) 3.2.2 Conditions and limitations of the different cleaning techniques 3.2.3 Comparison of the effectiveness of the different techniques in relation to the surface state of the specimen **3.3 Conditions and requirements for the different drying stages**	**(03 HRS)** **3.1 Selection of the test techniques in relation to the type of specimen and design specifications** **3.2 Treatment and preparation of the specimen** 3.2.1 Protection of areas not being examined 3.2.2 Selection of techniques for preparation and preliminary cleaning 3.2.3 Systems of cleaning, design and monitoring; 3.2.4 Intermediate drying, conditions and requirements for the various techniques **3.3 Application of the penetrating agent** 3.3.1 Comparison of the various techniques 3.3.2 Determination of special conditions depending on the examination requirements 3.3.3 Acceptable temperature intervals 3.3.4 Special cases of high and low temperature

	3.4 Application of the penetrant; various modes of application; penetration time; temperature **3.5 Removal of excess penetrant** 3.5.1 Various methods of removal depending on type of penetrant; water-dispersible; water-soluble; solvent-soluble; post-emulsifiable; drying **3.6 Application of the developer** 3.6.1 Various techniques for application of the developer **3.7 Observation of indications** 3.7.1 Conditions for the observation of coloured and fluorescent penetrating liquids 3.7.2 Lighting requirements 3.7.3 Observation sequence and time 3.7.4 False or irrelevant indications **3.8 Final cleaning/Post Cleaning** **3.9 Recording of the findings** 3.9.1 Test forms 3.9.2 Transfer of findings 3.9.3 Diagrams 3.9.4 Photography	3.3.1 Use of cold and hot air 3.3.2 Temperature and time **3.4 Inspection process** 3.4.1 Application of the penetrating agent a) application techniques, b) temperature, c) penetration time 3.4.2 Removal of excess penetrating agent a) various methods of removal depending on type of penetrant, water-dispersable, water-soluble, solvent-soluble, post emulsifiable; b) conditions for the application of lipophilic and hydrophilic emulsifiers; c) drying; d) requirements and precautions in the removal stage 3.4.3 Application of the developer a) various techniques, b) previous treatment of the developer **3.5 Observation of the findings** 3.5.1 Lighting conditions for coloured liquids and UV radiation for fluorescent liquids 3.5.2 Sequence and time of observation	3.3.5 Penetration time **3.4 Removal of the excess penetrating agent** 3.4.1 Removal techniques for the various systems 3.4.2 Design and monitoring of the removal stage 3.4.3 Post- emulsification 3.4.4 Lipophilic and hydrophilic emulsifiers **3.5 Techniques of development** 3.5.1 Treatment of the specimens prior to development 3.5.2 Various types of developer 3.5.3 Treatment, selection and control **3.6 Observation of the indications** 3.6.1 Lighting conditions and Wood radiation requirements, depending on the applicable techniques and characteristics of the specimen; 3.6.2 Method, time and sequence of the observations; 3.6.3 Methods and media for recording indications **3.7 Evaluation of test sensitivity** 3.7.1 Test pieces for comparison 3.7.2 Detection thresholds 3.7.3 Interpretation of indications depending on fabrication process

		3.5.3 Interpretation of the findings and identification of the type of defects 3.5.4 Spurious or non-relevant findings **3.6 Recording of findings** 3.6.1 Test forms 3.6.2 Localization schemes 3.6.3 Transfer of findings 3.6.4 Photographic techniques 3.6.5 Writing reports **3.7 Testing techniques for detection of leaks by means of liquid penetrants**	3.7.4 False, spurious or irrelevant indications 3.7.5 Evaluation of indications according to specifications, codes or tolerance criteria **3.8 Classification of the application techniques** 3.8.1 Criteria for classification and selection 3.8.2 Applications according to specimens and operational conditions **3.9 Test techniques for detecting leaks by means of penetrating liquids** 3.9.1 Evaluation of areas of applications and sensitivity
4. TEST EQUIPMENT AND MATERIALS	**(01 HR)** **4.1 Evaluation of the materials for testing** 4.1.1 Characteristic properties 4.1.2 Behaviour properties 4.1.3 Content of halogen, sulphur and other specific contaminants **4.2 Cleaning equipment** 4.2.1 Ultrasonics 4.2.2 Degreasing steam **4.3 Pulverizers and aerosols** 4.4 Installations for processing by immersion **4.5 Lighting, Measuring equipment and units**	**(01 HR)** **4.1 Evaluation of the materials used in the test** 4.1.1 Penetrating agents a) Characteristic properties, viscosity, density, surface tension, ignition point, halogen and sulphur content, color, fluorescence b) Behavior, drop expansion, wash ability, corrosion, preservation, stability under light and UV radiation 4.1.2 Removers a) Characteristic properties and behavior b) Granulometry and apparent volume	**(03 HRS)** **4.1 Formulation of the penetrating liquids used in various techniques** 4.1.1 Types of dyes and pigments 4.1.2 Penetrants for prior cleaning and for removal 4.1.3 Solvents 4.1.4 Lipophilic and hydrophilic emulsifiers 4.1.5 Characteristics and properties 4.1.6 Developers 4.1.7 Physicochemical properties and characteristics 4.1.8 Form of presentation and use **4.2 Evaluation of materials**

	4.6 Ultraviolet radiation lamps (black light) 4.6.1 Efficiency types and characteristics 4.6.2 Measurements of ultraviolet radiation intensity 4.6.3 Units (micro watts/cm2)	c) Sedimentation and compaction 4.1.3 Emulsifiers characteristic properties and behavior 4.1.4 Developers a) Characteristic properties and behavior b) Granulometry and apparent volume c) Sedimentation d) Evaluation of processes e) Use of standardized work pieces **4.2 Cleaning equipment** 4.2.1 Degreasing vapor **4.3 Compressed air equipment** 4.3.1 Air filters 4.3.2 Supply of cold and hot air 4.3.3 Compressed air pistols 4.3.4 Electrostatic pulverizers 4.3.5 Aerosols **4.4 Stationary installations for processing by immersion** 4.4.1 Automatic instal1ations **4.5 Light sources and light meters** 4.5.1 Ultraviolet radiation sources (black light) and meters for measuring UV radiation intensity 4.5.2 Checking the efficiency of ultraviolet lamps 4.5.3 Cabinets for observation of fluorescent penetrating liquids	4.2.1 Characteristic properties and behavior 4.2.2 Test methods for the evaluation 4.2.3 Standardized test pieces (ASTM, MIL, JIS, IRAM) for evaluation of processes and rating of procedures **4.3 Equipment and accessories applicable to the test under way** 4.3.1 Pulverization systems and equipment for 1iquid as 4.3.2 Isothermic and adiabatic compressors 4.3.3 Electrostatic pulverizers 4.3.4 Stationary installations for manual and automatic processing. **4.4 Lighting for direct observation and ultraviolet radiation sources** 4.4.1 Measuring instruments 4.4.2 Devices for evaluating pigment fluorescence and efficiency of ultraviolet lamps

		4.6 Standardized work pieces for evaluating processes and qualifying procedures 4.6.1 ASTM, MIL, JIS,IRAM test pieces 4.6.2 Non-standardized test pieces for checking penetrability 4.6.3 Equipment for checking fluorescence and efficiency of UV lamps	
5. CODES, STANDARDS, PROCEDURES AND SAFETY	**(01 HR)** **5.1 General knowledge** 5.1.1 National, regional and international codes and standards 5.1.2 General knowledge of specifications **5.2 Industrial safety standards** **5.3 Instructions for the test** 5.3.1 Interpretation	**(02 HRS)** **5.1 Standards applicable to liquid penetrant testing** 5.1.1 Test methods 5.1.2 Materials for the test (ASTM, DIN, MIL, IRAM) 5.1.3 ASME code **5.2 Test specifications and procedures** 5.2.1 Interpretation 5.2.2 Formulation of instructions for the test **5.3 National standards for liquid penetrant testing and testing personnel** a) quality control of the test and procedure for its administration, b) quality assurance requirements	**(09 HRS)** **5.1 Examination specifications** 5.1.1 Function of design engineering 5.1.2 Design and building codes 5.1.3 ASME Code **5.2 Standards specific to liquid penetrant testing** 5.2.1 National and international standards (ASTM, DIN, MIL, IRAM) 5.2.2 Interpretation of specifications, codes and standards **5.3 Test procedures** 5.3.1 Formulation of test procedures 5.3.2 General and specific procedures **5.4 Procedure Writing** **5.5 Safety in penetrant testing**

		5.4 Problems of industrial safety in the use of chemical and inflammable products 5.4.1 Applicable safety standards 5.4.2 Safety conditions required for the use of UV light 5.4.3 Drafting of safety instructions for the personnel involved 5.4.4 Safety factors applicable to the test 5.4.5 Environmental protection	
6. PRESENTATION AND RECORDING OF RESULTS	**(02 HRS)** **6.1 Presentation of results on test forms** **6.2 Recording of indications** 6.2.1 To locate and identify them with reference to the test piece 6.2.2 By photography **6.3 Recognition of findings** 6.3.1 Indications of defects 6.3.2 Spurious (false) indications	**(01 HR)** **6.1 Presentation of results on test forms** **6.2 Recording of indications** 6.2.1 To locate and identify them with reference to the test piece 6.2.2 By photography **6.3 Recognition of findings** 6.3.1 Indications of defects 6.3.2 Spurious (false) indications	**(02 HRS)** **6.1 Preparation of reports on the testing** **6.2 Preparation and completion of the report form** **6.3 Documentation of the findings** **a) to locate the indication within the component** b) knowledge of documentation systems c) management and control of complete documentation
7. INTERPRETATION OF RESULTS, LIMITATION		**(01 HR)** **7.1 Presentation of results** **7.2 Interpretation of findings with reference to the manufacturing process** a) evaluation of results according to the criteria of the procedure and specifications	**(01 HR)** **7.1 Presentation of results** **7.2 Thresholds of detection** a) evaluation of results according to the criteria of the procedure and specifications b) additional possibilities for making the results more conclusive **7.3 Interpretation of findings with reference to the manufacturing process**

		b) additional possibilities for making the results more conclusive **7.3 Sensitivity and limitations** **7.4 Applications of penetrant testing and other methods of testing for surface flaws** **7.5 Safety:** 7.5.1 Implementation of industrial safety standards in facilities and equipment and in their operation; hazards of using toxic and inflammable materials; materials, equipment and accessories for the protection of persons and facilities ~~**7.6 Instruction writing**~~	**7.4 Applications of penetrant testing and other methods of testing for surface and subsurface flaws**
8. PRACTICAL	**(11 HRS)** **8.1 Practical** 8.1.1 Proper handling of penetrant materials and safety 8.1.2 perform the cleaning methods of work pieces; carrying out drying of a work piece; 8.1.3 perform types of the removal of excess penetrant properly, applying the precautions and fulfilling the requirements; 8.1.4 carry out the correct application of the developer;	**(13 HRS)** **8.1 Instruction Writing** **8.2 Practical** 8.2.1 Same as for Level 1 + Interpretation and evaluation, recording of test results and preparation of test reports 8.2.2 Choose appropriate method for a given work piece 8.2.3 Training to follow guidelines in codes and standards	**N/A**

	8.1.4 determine the conditions for observation, differentiating between them on the basis of whether the liquids are colored or fluorescent; 8.1.5 familiarize with the instruments used to measure required light intensities; recognize various types of lighting equipment. 8.1.7 Carrying out penetrant test on test specimens 8.1.8 Identifying relevant and non-relevant indications 8.1.9 Training to follow guidelines in codes and standards		
	24 HRS	**30 HRS**	**60 HRS**

Table 2 — Minimum training requirements

NDT method		Level 1 h	Level 2 h	Level 3 h
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TT		40	80	40
RT		40	80	40
UT		40	80	40
VT		16	24	24
NOTE For RT, training hours do not include radiation safety training.				

Method and Topic of the Lecture	Level 1	Level 2	Level 3
RT			
1. GENERAL KNOWLEDGE	**(04 HRS)** **1.1 INTRODUCTION –NDT** 1.1.1 Definitions 1.1.2 Characteristics of NDT as a technology and Reasons for using NDT 1.1.3 Conventional NDT methods a) Visual testing b) Liquid penetrant testing c) Magnetic particle testing d) Radiographic testing e) Ultrasonic testing f) Eddy current testing g) Leak testing 1.1.4 Advantages and limitations in the common NDT methods. 1.1.5 Responsibilities of personnel certified to level 1, 2 and 3 personnel **1.2 INTRODUCTION -MATERIALS** 1.2.1 Properties of materials (metal and non-metal) 1.2.2 Properties of metals 1.2.3 Discontinuities and defects 1.2.4 Primary processes and related defects a)Casting b) Welding c) Forging d) Rolling e) Heat treatment f) Machining	**(09 HRS)** **1.1BASIC PRINCIPLES OF NDT** 1.1.1 Definitions, physical principle and methodology of applications of basic NDT methods: VT, PT, MT, RT, UT, ET, LT 1.1.2 Area of application of common NDT methods 1.1.3 Advantages and limitations of common NDT methods 1.1.4 Other in NDT methods 1.1.5 Certification of NDT Personnel 1.1.6 Importance of quality control and quality assurance **1.2 INTRODUCTION - MATERIALS** 1.2.1 Structures of metals and alloys 1.2.2 Physical and mechanical properties of materials (metallic and non-metallic) 1.2.3 Discontinuities, defects and indications, 1.2.4 Inherited, processing and In-service discontinuities 1.2.5 Primary processes and inherited discontinuities 1.2.6 Metallurgical processes and discontinuities derived for them	**(16 HRS)** **1.1 NDT, MATERIALS AND PROCESSES** 1.1 NDT methods- knowledge of at least 4 NDT methods at level 2 1.1.1 Scope and limitations: comparison of different NDT methods 1.1.2 Selection of methods 1.2 Technology of materials 1.2.1 Discontinuities and defects in materials. Classification according to location and morphology 1.2.2 Properties of materials 1.2.3 Nature of materials and solid state changes in materials 1.2.4 Phase Diagram and allotropy, ferrous metals 1.2.5 Non-ferrous metals and plastics 1.2.6 Nature of manufacturing 1.2.7 Casting process 1.2.8 Welding process 1.2.9 Rolling process 1.2.10 Forging process 1.2.11 Powder metallurgy 1.2.12 Machining fundamentals 1.2.13 miscellaneous processes 1.2,14 Mechanism of in-service defect formation (corrosion, wear, tear, fatigue crack,

	g) Plating 1.2.5 In-service defects a) Overload b) Fatigue c) Corrosion d) Erosion e) Brittle fracture f) Others	1.2.7 Materials in service and discontinuities formed during in-service	creep, hydrogen embrittlement, stress corrosion cracking, etc 1.2.13 Surface finishing **(06 HRS)** **1.2. QUALITY ASSURANCE AND STANDARDIZATION** 1.2.1 Quality assurance 1.2.1.1 Basic principles for the application of quality assurance 1.2.1.2 Organization of quality assurance, Quality manual, Quality control, Auditing of Quality. 1.2.1.3 Management and control of quality assurance documentation, quality control of testing 1.2.1.4 Certification and accreditation of NDT facilities 1.2.1.5 Reports on testing, documentation systems 1.2.2 Standardization 1.2.2.1 Definition of standardization, principles for writing of standards 1.2.2.2 Codes, standards, specification procedures and instructions 1.2.2.3 Procedure Writing, i.e format, structure, and content of procedures 1.2.2.4 Procedure validation- 1.2.3 Reports and protocols **(04 HRS)**

			1.3 ORGANIZATION AND ADMINISTRATION OF NDT 1.3.1 Organization and administration of NDT 1.3.1.1 Safety: a) Implementation of industrial safety standards in facilities and equipment and in their operation b) Hazards of using toxic and inflammable materials c) Materials, accessories and equipment, for the protection of persons and facilities 3.1.2 Organization a) Organization structure of NDT Department or NDT organization b) Equipment for work under way; Logistic provisions c) Testing on production lines; Flow of materials; Work shifts d) Maintenance of equipment and facilities 1.3.1.3 Costs a) Investments in equipment b) Direct and indirect staff costs c) Calculation and analysis of costs and profitability 1.3.1.4 Equipment selection and facility design 1.3.1.5 Operating procedures and record keeping **(04 HRS)**

			1.4. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL 1.4.1 Training, Qualification and Certification of NDT personnel 1.4.1.1 National standards for the qualification and certification of personnel. 1.4.1.2 Regional and international recommendations, e.g ISO 9712 1.4.1.3 Organization of courses and training in NDT methods 1.4.1.4 Code of ethics **(10HRS)** **1.5. REVISION OF FOUR MAIN NDT METHODS**

2. PHYSICAL PRINCIPLES AND FUNDAMENTALS	**(03 HRS)** **2.1 Penetrating radiation** 2.1.1 Atomic Structure 2.1.2 Isotope and radioisotopes 2.1.3 Artificial and natural radioisotopes 2.1.4 Electromagnetic spectrum 2.1.5 Particulate and electromagnetic radiation 2.1.6 X rays and gamma rays 2.1.7 Wavelength and energy 2.1.8 X ray and gamma ray spectra 2.1.9 KVp, KVc, KeV, MeV 2.1.10 Inverse square Law for distance/intensity 2.1.11 General properties of propagation of penetrating radiation 2.1.12 Units related to penetrating radiation **2.2 Principles of radioactive decay** 2.2.1 Definition of radioactivity 2.2.2 Unit of radioactivity (Curie and Becquerel) 2.2.3 Specific activity 2.2.4 Decay equation 2.2.5 Half-life **2.3 Interaction of radiation with matter**	**(03 HRS)** **2.1 Nature of penetrating radiation** 2.1.1 Atom and molecule 2.1.2 Atomic Structure 2.1.3 Atomic mass and atomic number 2.1.4 Isotope and radioisotopes 2.1.5 Artificial and natural radioisotopes 2.1.6 Particulate and electromagnetic radiation **2.2 Principles of radioactive decay** 2.2.1 Definition of radioactivity 2.2.2 Unit of radioactivity (Becquerel and Curie) 2.2.3.Specific activity 2.2.4 Types of radiation (alpha, beta, gamma and neutron) 2.2.5 Radiation intensity and k-factor 2.2.6 Radioactive Decay and decay equation 2.2.7 Half life 2.2.8 Modes of decay (alpha emission, bet emission and gamma emission) **2.3 X rays and gamma rays** 2.3.1 Electromagnetic spectrum	**(03 HRS)** **2.1 Nature of ionizing radiation** 2.1.1 Corpuscular and electromagnetic radiation 2.1.2 X-rays and gamma rays and their spectra 2.1.3 Wavelength and energy **2.2 Radioactive decay** 2.2.1 Radioactivity, half –life 2.2.3 Decay series 2.2.4 Artificial and natural sources 2.2.5 Alpha and beta particles, neutrons 2.2.6 Measurement of intensity, k-factor **2.3 Interaction of radiation with matter** 2.3.1 Absorption, scattering, photoelectric effect, Compton effect, pair production 2.3.2 Absorption coefficient; Half and tenth value layers 2.3.3 Calculation of attenuation coefficient for simple materials and compounds 2.3.4 Radiographic equivalents 2.3.5 Build-up factors 2.3.6 sky-shine effect **2.4 Measurement of ionization and units**

	2.3.1 Photoelectric effect, Compton effect, pair production 2.3.2 Absorption coefficient, half value layer (HVL), tenth value layer 2.3.4 Ion and ionization **2.4 Detection of ionizing radiation** 2.4.1 Ionization Chamber 2.4.2 Geiger Muller Counter 2.4.3 Scintillation detector 2.4.4 Proportional counter	2.3.2 Wavelength and energy 2.3.3 X ray and gamma ray spectra 2.3.4 KVp, KVc, KeV, MeV 2.3.5 Inverse square Law for distance/intensity 2.3.6 General properties of propagation of x and gamma ray **2.4 Interaction of radiation with matter** 2.4.1 Absorption, dispersion, photoelectric effect, Compton effect, pair production 2.4.2 Absorption coefficient 2.4.3 Build-up factor 2.4.4 Half-value thickness and tenth value thickness 2.4.4 Use of tables for calculating attenuation of gamma and X-radiations **2.5 Detection of ionizing radiation** 2.5.1 Ionization Chamber (principle of operation, range of detection, advantages and limitation) 2.5.2 Geiger Muller Counter (principle of operation, range of detection, advantages and limitation)	2.4.1 Detection of radiation by ionization, scintillation etc. **2.5 Principles of detection by means of film, fluorescent material or electric and electronic systems in radiographic testing**

		2.5.3 Scintillation detector (principle of operation, range of detection, advantages and limitation) 2.5.4 Proportional counter (principle of operation, range of detection, advantages and limitation)2.8 Attenuation of sound: Cause and effect; principles of measurement of attenuation **2.6 Principles of X and gamma ray detection** 2.6.1 Film, its accuracy of measurement and limitation 2.6.2 Fluorescent material, its accuracy of measurement and limitation 2.6.3 Electronic detection, its accuracy of measurement and limitation	

3. EQUIPMENT - RADIATION SOURCE	**(03 HRS)** **3.1 X ray equipment** 3.1.1 Generation of x-ray (source of electron, acceleration of free electrons and target material) 3.1.2 Stationary and mobile units 3.1.3 X ray generators and tubes (glass and metal ceramic), target material and characteristics, configuration, focus, heat dissipation 3.1.4 Design of tubes (standard tube; rod anode tube; short anode tube).. 3.1.5 X-ray tube head, power source 3.1.6 X-ray control panel (tube voltage, tube current, exposure time) 3.1.7 Cooling (gas, water, oil) 3.1.8 X-ray quality and quantity 3.1.9 Accessories **3.2 Gamma ray sources** 3.2.1 Gamma ray spectrum 3.2.2 Common radiography sources (source size, half-life, energy, activities) 3.2.3 Radiography source assembly 3.2.4 Types of gamma projector, shielding, collimators 3.2.5 Handling of radiography projector	**(03 HRS)** **3.1 X-ray equipment** 3.1.1 Mechanism of x-ray generation 3.1.2 X- ray spectrum (continuous and characteristic x-rays) 3.1.3 Requirements for x-ray generation (electron source, accelerator, target material) 3.1.4 X-ray tube head 3.1.5 X-ray tube (cathode, anode, focal spot) 3.1.6 X-ray tube window 3.1.7 Tube voltage and current 3.1.8 Control panel 3.1.9 X-ray generation efficiency 3.1.10 Heat dissipation 3.1.11 Pre-filtering and Inherent filtering 3.1.12 Work cycle 3.1.13 Determination of focus length 3.1.14 Directional and panoramic x-ray machine 3.1.15 Types of circuits for X ray equipment 3.1.15 Classification and selection of X ray machine 3.1.16 Radiation safety features	**(03 HRS)** **3.1 Industrial radiation sources** 3.1.1 X ray generators, 3.1.2 Beam opening characteristics 3.1.3 X-ray flash devices 3.1.4 Rod anode devices 3.1.5 Micro-focus devices; 3.1.6 High-voltage devices. 3.1.7 Line focus tubes 3.1.8 Rotary anode tubes 3.1.9 Van Der Graft, linear accelerators, betatrons 3.1.10 Inherent filtering 3.1.11 Hardening effect 3.1.12 Method for measurement of focal spot according to standard 3.1.13 Equipment for gamma radiation and neutron generators 3.1.14 Purchase, acceptance, operation and maintenance 3.1.15 Shielding, filtering and collimation 3.2 Facilities for industrial radiography (design and construction of an exposure room) **3.3 Accessories**

		3.2 Modern X-ray equipment 3.2.1 Van De Graf, 3.2.2 Linear accelerators, 3.2.3 Betatrons 3.2.4 Microfocus x-ray 3.2.5 Radioscopy **3.3 Gamma ray sources** 3.3.1 Radioactive sources commonly used for industrial radiography and their characteristics 3.3.2 Factors determining the choice of radiography sources (half-life, energy, specific activity, availability, focal spot size) 3.3.3 Classification of Gamma cameras (Class P, M and F) 3.3.4 Gamma camera designs (torch type, shutter type, rotating type, remote control type, and small controlled area type) 3.3.5 Source changer 3.3.6 Collimators 3.3.7 Handling of gamma camera **3.4 Crawler** 3.4.1 X-ray crawler 3.4.2 Gamma ray crawler **3.5 Maintenance of x-ray equipment and gamma camera**	

		3.6 Comparison between the use of x-ray equipment and gamma camera	
4. PHOTOGRAPHIC AND NON-PHOTOGRAPHIC RECORDING	**(03HRS)** **4.1 Photographic recording (film for X ray and gamma ray radiography)** 4.1.1 Film construction (base layer, emulsion layer and protective layer) 4.1.2 Radiography image formation 4.1.3 Film characteristics (film density, film speed, film contrast, film definition) 4.1.4 Characteristic curves, radiographic quality 4.1.5 Film Screen-Lead screens (intensifying effect; filtering effect; film to screen contact) 4.1.6 Fluorescent screen **4.2 Non-photographic recording** 4.2.1 Fundamental of digital image processing 4.2.2 Description of the fluoroscopic test	**(06 HRS)** **4.1 Photographic recording (Gamma ray, X-ray)** 4.1.1 Structure and composition of radiography film (protective layer, emulsion layer, protective layer, single and double coating film) 4.1.2 Principle of image formation 4.1.3 Characteristic curve, influence of radiation energy 4.1.4 Film Characteristics (Film quality, Film graininess, Film density, Film contrast, Film definition and sharpness-effect of graininess and secondary electron) 4.1.5 Film classification according to speed, type of screen used and classification according to various standards 4.1.6 Film packaging (enveloped, ready packed enveloped, ready packed rolled, 4.1.7 Film storage (processed and unprocessed)	**(04 HRS)** **4.1 Photographic recording** 4.1.1 Films used in radiography, principles, properties, types of emulsions (granularity), influence of radiation, energy, characteristic curves 4.1.2 Radiographic quality, density, contrast, definition, sharpness 4.1.3 Types of films for industrial radiography 4.1.4 Sensitometric / characteristic curves 4.1.5 Exposure curves 4.1.6 Lead and fluorescent screens **4.2 Digital radiography**

		4.1.8 Lead, salt and fluorescent screens 4.1.9 Screen for Co-60 and LINAC 4.1.10 Brightness and penumbra responses of fluorescent screens 4.1.11 Sensitometric curves/characteristic curves/H and D Curve 4.1.12 Exposure curves 4.1.13 Choice of film and screen 4.1.14 Other accessories used in conjunction with film (densitometer, film hanger, lead letters and numbers, film cassette) **4.2 Non-photographic recording (fluoroscopy test)** 4.2.1 Radiation contrast, noise and imaging requirement 4.2.2 Image intensifiers 4.2.3 TV systems 4.2.4 Xero radiography **4.3 Non-photographic recording (digital radiography)** 4.1.1 CCD systems, Scintillation screens 4.1.2 Digital direct image recording 4.1.3 Digital image analysis and enhancement	

5. WORK PARAMETERS AND CONDITIONS	**(02HRS)** **5.1 Parameters and work conditions** 5.1.2 Geometric principles of image formation, umbra and penumbra 5.1.3 Relation between geometrical unsharpness with focal spot size, source to film distance, source to object distance, object to film distance 5.1.4 Image density, factors affecting it 5.1.5 Image quality, sensitivity, and radiography contrast and radiography definition 5.1.6 Scattered radiation, types, causes, and control 5.1.7 Use of screens, masks, filters 5.1.8 Image quality indicators (IQI) according to various standards, characteristics, types and placement 5.1.9 Radiography exposure and factors governing it 5.1.10 Exposure charts for X-rays and gamma rays 5.1.11 exposure calculations **5.2 Care in the handling and conservation of film** 5.2.1 Film handling	**(06 HRS)** **5.1 Parameters and working conditions** 5.1.1 Geometrical principles, formation of umbra and penumbra 5.1.2 Image density, factors which affect it 5.1.3 Image quality, factors which affect it 5.1.4 Radiography contrast (film contrast and subject contrast) and factors affecting them 5.1.5 Radiography definition (geometrical unsharpness and inherent unsharpness) and factor affecting them 5.1.6 Minimum source to Film distance 5.1.7 Scattered radiation (definition, types, and causes) 5.1.8 Methods of avoiding scattered radiation (Use of screens, masks, filters, collimators) 5.1.9 Radiography sensitivity (concepts of sensitivity) 5.1.10 Image quality indicators-IQI (types of IQI according to different standards),	**(03 HRS)** **5.1 Operating parameters and image quality in radiographic testing** 5.1.1 Radiographic sensitivity 5.2 Operating techniques for real-time fluoroscopy and direct digital image recording **5.2.1 Testing sensitivity, fluctuation and resolution** 5.2.2 Evaluation of digital image data **5.3 Film processing, equipment, facilities and reagents** 5.3.1 Handling and conservation 5.3.2 Special situations 5.3.3 Influence of the observations conditions in defect detection 5.3.4 Lighting control in viewers 5.3.5 Brightness requirements 5.3.6 Causes of defective radiographs and correction there of 5.3.7 Processing defects 5.3.8 Systematic control of radiographic quality **5.4 Conditions for observing radiographs** 5.4.1 Lighting and perceptibility

	5.2.2 Storage of processed and unprocessed films 5.2.3 Loading and unloading film 5.2.4 Darkroom layout, equipment, and chemicals, 5.2.5 Processing of film 5.2.6 Unsatisfactory radiographs and misleading images **5.3 Viewing of radiographs** 5.3.1 Eye Adaptation 5.3.2 Viewing requirement 5.3.3 Viewing room lighting requirement 5.3.4 Viewing accessories, viewer, densitometer, light-meter **5.4 Evaluation of radiograph quality:** 5.4.1 Presence of artifacts 5.4.2 Density measurement 5.4.3 Location marker 5.4.4 Film identification marker 5.4.5 Image quality indicators (types, designation, placement, visible wire/hole)	5.1.11 Choices of correct IQI designation 5.1.12 Sensitivity calculation 5.1.13 IQI positioning 5.1.14. Radiography exposure and factors affecting it 5.1.15 Choice of energy 5.1.16 Exposure curves for X rays, gamma rays 5.1.17 Exposure calculations (by past experience, using exposure curve, using characteristic curve, using special guided slide) 5.1.18 Preparation of exposure curves for x- and gamma rays 5.1.19 Application of exposure curve for exposure calculation (direct reading, for different source to film distances, for different materials, for different types of film) 5.1.20 Choice of films 5.1.21 Choice of screens 5.1.22 Magnification and distortion of the projected image 5.1.23 Fluoroscopy, evaluation of sensitivity, selection of KVp **5.2 Film processing**	

		5.2.1 Function and design of darkroom 5.2.2 Safety lamps 5.2.3 Equipment (manual and automatic processing unit, drying cabinets) 5.2.4 Chemistry of processing solution (developer solution, stop bath, fixer) 5.2.6 Care to be taken in handling and conserving the film 5.2.7 Checking on the use of reagents, temperatures, processing time 5.2.8 Processing procedure in darkroom (film unloading, development, rinsing, fixation, washing and drying) 5.2.9 Misleading image and unsatisfactory radiographs 5.2.10 Special situations **5.3 Viewing of the radiographs** 5.3.1 General information, lighting, viewer 5.3.2 Influence of the observation conditions on the detection of defects 5.3.3 Checking the lighting in the viewer	

		5.3.4 Brightness requirements **5.4 Evaluation of radiographic quality** 5.4.1 Causes and correction of defective radiographs 5.4.2 Processing defects, high density, 1ow density, contrast, definition, fog 5.4.3 Image quality indicators, IQI (types, designation, visible wire/hole, and placement) 5.4.4 Identification marker 5.4.4 Identification 5.4.5 Density measurement 5.4.6 Systematic control of radiographic quality	
6. DEFECTOLOGY	**(01HRS)** **6.1 Basic relationship between image and object** **6.2 Radiographic indication of defects**	**(02 HRS)** **6.1 Basic factors** 6.1.1 Relation between image and object **6.2 Interpretation of radiographic images** 6.2.1 Requirement for radiography interpreter 6.2.2 Reference radiographs (welding, casting, corrosion, etc.). 6.2.3 Discontinuities in welds and their radiographic appearance	**(03 HRS)** **6.1 Interpretation of radiographic images** 6.1.1 Relation between image and object **6.2 Requirement for radiography interpreter** 6.2.1 Standard reference radiographs (IIW, ASTM, etc for welding, casting, corrosion, etc.).

		6.2.4 Discontinuities in casting and their radiographic appearance 6.2.5 Acceptance and rejection criteria 6.2.5 Factors affecting defect detectability (beam direction; geometric distortion; increase in wall thickness; Imaged thickness range; Thickness ranges for X- and g-rays, Number of exposures	6.2.2 Discontinuities in welds, their source, effect to weld integrity and their radiographic appearance 6.2.3 Discontinuities in casting, their source, effect to product integrity and their radiographic appearance 6.2.4 Influence on detectability (beam direction; geometric distortion; increase in wall thickness; Imaged thickness range; Thickness ranges for X- and gamma-rays; Number of exposures vs. Distortion angle)

7. SELECTIONS OF TECHNIQUES	**(02 HRS)** **7.1 Influence of properties of the material** **7.2 Exposure techniques according to the geometry of the object** 7.2.1 Single wall/single image 7.2.2 Double wall/single image 7.2.3 Double wall/double image 7.2.4 Panoramic and directional exposure 7.2.5 Thickness compensation 7.2.6 Masks	**(06 HRS)** **7.1 Influence of the properties of the material** 7.1.1 Single materials 7.1.2 Compound materials **7.2 Basic consideration for technique selection** 7.2.1 Fundamental consideration 7,2,3 Geometry of the specimen **7.3 Selection of film, screens and radiation energy** **7.4 Exposure techniques depending on the geometry and accessibility of the object** 7.4.1 Directional Technique 7.4.2 Panoramic Technique 7.4.3 Single wall/single image 7.4.4 Double wall/single image 7.4.5 Double wall/double image 7.4.6 Panoramic exposure **7.5 Radiography of welds** 7.5.1 Seam welds 7.5.2 Circumferential welds in pipes 7.5.3 Nozzle welds 7.5.4 Tee welds 7.5.6 Diagnostic length of a weld **7.6 Casting examination-Thickness compensation method** 7.6.1 Single thickness	**(04 HRS)** **7.1 Influence of the properties of materials** 7.1.1 Compound materials **7.2 Exposure technique depending on the geometry and accessibility of the object** 7.2.1 Single wall/single image 7.2.2 Double wall/single image 7.2.3 Double wall /double image 7.2.4 Panoramic exposure 7.2.5 Compensation for thickness 7.2.6 Masks ***7.3 Probability of detection (POD) according to type, size, position and orientation of the*** *defect*

		7.6.2 Compensation thickness method 7.6.3 Diagonal method 7.6.4 Multifilm method **7.7 Determination of defect depth** 7.7.1 Right angle method 7.7.2 Shift method 7.7.3 Lead marker method	

8. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES.	**(02 HRS)** **8.1 Codes, standards, specifications and procedures** 8.1.1 General knowledge of codes and standards as applied to radiographic testing 8.1.2 General knowledge of specifications and procedures for radiographic testing 8.1.3 Examples of codes and standards related to industrial radiography inspection **8.2 Written instruction** 8.2.1 Content of written instruction 8.2.2 Performance of tests in accordance with written instructions	**(06 HRS)** **8.1 General knowledge of codes and standards** 8.1.1 Differences between codes, standards, specifications and procedure 8.1.2 Organizations developing codes, standards, specifications and procedure 8.1.3 Classification of codes, standards, specifications and procedure (for products, testing methods, qualification and certification of personnel, radiation protection, reference radiographs) **8.2 Codes and standards related to NDT** 8.2.1 Standards for terminology 8.2.2 Standards for equipment 8.2.3 Standards for testing method 8.2.4 Standards for Education, Training and Certification of NDT Personnel **8.3 Codes and standards related to industrial radiography** 8.3.1 ISO Standards 8.3.2 International Institute of Welding (IIW)	**(09 HRS)** **8.1 National and international codes and standards for radiographic testing** 8.1.1 Bodies producing standards (ISO. ASTM, ASME, BS, EN, etc.) 8.1.2 Interpretation of some standards related to radiography testing (e.g ASME Section V, Article 2) **8.2 Specifications for radiographic testing** **8.3 Procedure writing** 8.3.1 Requirement for written procedure in code and standard 8.3.2 Content of radiography procedure 8.3.3 Radiographic procedure writing as per given reference codes.

		8.3.3 International Atomic Energy Agency (IAEA) 8.3.4 American Society for Mechanical Engineer (ASME) 8.3.5 British Standard 8.3.6 Japanese Industrial Standard 8.3.7 Standards related to the application of digital radiography **8.4 Procedure and instruction** 8.4.1 Interpretation of procedure and compilation of test instruction 8.4.2 Content and Interpretation of procedures and instruction 8.4.3 Evaluation of test performance carried out by a radiographer 8.4.4 Preparation of written instruction for radiography testing of given specimens (plates and pipes) **8.5 Performance of test in accordance with written instructions** 8.5.1 Recording of operating conditions on test forms 8.5.2 Execution of radiography inspection in accordance with the written instruction 8.5.3 Evaluation of tasks carried out by level 1 operator	

		8.6 Instructions for testing in special situations 8.6.1 Range of application of the test, equipment and technique 8.6.2 Standards, codes, and procedures for radiography a) ASTM E-94, E-142 and other applicable standards b) Radiographic techniques and setups c) Applicable employer procedures d) Procedure for radiograph parameter verification e) Radiographic reports	

9. PERSONAL SAFETY AND RADIATION PROTECTION	**(16 HRS)** **9.1 Radiation quantity and units** 9.1.1 Exposure 9.1.2 Absorbed dose 9.1.3 Equivalent dose 9.1.4 Dose limit for workers and publics **9.2 Dangers of excessive Biological effects of exposure to X rays and gamma rays** 9.2.1 Source of radiation exposure to human being (natural, manmade and accidental) 9.2.2 Acute and chronic exposure 9.2.3 Somatic and genetic effects 9.2.4 Stochastic and no stochastic effect 9.2.5 Wearing of monitoring Film badges 9.2.6 Reading of pocket dosimeters and recording its daily readings 9.2.7 Thermoluminiscent dosimeter (TLD) **9.3 Method of controlling external exposure** 9.3.1 Time 9.3.2 Distance 9.3.3 Shielding **9.4 Work place monitoring** 9.4.1 Purpose of monitoring	**(12 HRS)** **9.1 Radiation quantity and units** 9.1.1 Exposure 9.1.2 Absorbed dose 9.1.3 Equivalent dose 9.1.4 Effective equivalent dose 9.1.4 Dose limit for workers, members of public and trainees **9.2 Biological effects of exposure to X-rays and gamma rays** 9.2.1 Source of radiation exposure to human being (natural, manmade and accidental) 9.2.2 Acute and chronic exposure 9.2.3 Somatic and genetic effects 9.2.4 Stochastic and no stochastic effect **9.3 Personnel monitoring** 9.3.1 Film badges dosimeter 9.3.2 Pocket dosimeters and recording its daily readings 9.3.3 Thermoluminiscent dosimeter 8.3.4 Storage of personnel monitoring record **9.4 Method of controlling external exposure** 9.4.1. Time 9.4.2, Distance 9.4.2 Shielding	**(05 HRS)** **9.1 Radiation and its effects** 9.1.1 Biological effects of radiation 9.1.2 Mechanism of radiation damage to human cell 9.1.3 Effect of radiation (somatic, genetic and risk of the pregnant women) 9.1.4 Comparison of risk due to other activities (e.g smoking) 9.1.5 International regulations and recommendations for radiation protection **9.2 Equipment and facilities** 9.2.1 Design and calculation of shielding for equipment and facilities 9.2.2 Design of packaging for the transport of radioactive sources 9.2.3 Verification of radiation of leaks from X-ray and gamma ray equipment **9.3 Operational procedures** 9.3.1 Safety in equipment and faci1ities for industrial radiography 9.3.2 Maintenance of equipment for scintiscanning **9.4 Radiation safety conditions for work in the field** 9.4.1 Operational procedure 9.4.2 Precaution for site gamma radiography

	9.4.2 Radiation survey-meter, reading and interpreting meter indications 9.4.3 Application of radiation survey-meter (e.g confirming source inside the projector etc) 9.4.4 Recording radiation survey results 9.4.5 Calibration frequency, calibration expiration action, battery check importance **9.5 Radiographic works in exposure room** 9.5.1 Preparation prior to commencement of works (safety equipment and accessories) 9.5.2 Safety requirement for exposure rooms (dose reading, warning light) 9.5.3 Area monitoring before, during and after radiography works **9.6 Radiography works at open and semi open sites** 9.6.1 Preparation prior to commencement of works (safety equipment and accessories) 9.6.2 Establishment of restricted area; posting and surveillance of restricted areas, 9.6.3 Use of time, distance, and shielding to reduce personnel radiation exposure,	**9.5 Work place monitoring** 9.5.1 Purpose of monitoring 9.5.2 Radiation surveymeter, reading and interpreting meter indications 9.5.3 Application of radiation surveymeter (e.g confirming source inside the projector, etc.) 9.5.4 Recording radiation survey results 9.5.5 Calibration frequency, calibration expiration action, battery check importance **9.6 Safety requirement for the operation in exposure room** 9.6.1 Introduction to a radiography exposure room 9.6.2 Requirements for an X ray and gamma ray exposure rooms 9.6.3 Shielding calculation of exposure room 9.6.4 Layout of x- and gamma ray exposure room 9.6.5 Preparation prior to commencement of works (safety equipment and accessories) 9.6.6 Area monitoring before, during and after radiography works	**9.5 Radiological safety responsibility** 9.5.1 Operating organizations 9.5.2 Radiation protection Officers 9.5.3 Radiographers 9.5.4 Radiography client **9.6 Radiation Protection Program** 9.6.1 Objective and scope 9.6.2 Radiation Protection Program Content 9.6.3 Control of industrial radiography source **9.7 Security of radioactive source used in industrial radiography** 9.7.1 Categorization of radiography sources 9.7.2 Security level 9.7.3 Security function, security objective 9.7.4 Radiation security program 9.7.5 Storage of radiography source

	9.6.4 Use of collimators to reduce personnel exposure 9.6.5 Use of "source changers" for gamma ray sources **9.7 Transportation of exposure devices and sources** 9.7.1 Transportation within premises 9.7.2 Transportation outside premises 9.7.3 Transport index 9.7.4 Labeling **9.8 Storage of radiography equipment** 9.8.1 Vehicle storage 9.8.2 Storage for x-ray machine 9.8.3 Storage of gamma ray exposure device **9.9 Emergency procedures** 9.9.1 Equipment required during emergency 9.9.2 Emergency procedure involving x-ray equipment 9.9.3 Emergency procedure involving gamma ray source while in use (failure of source to return to safe shielded conditions, source detached from the device) 9.9.4. Emergency procedure involving gamma ray source while not in use (Vehicle	**9.7 Safety requirement for the operation at the open and semi open sites** 9.7.1 Preparation prior to commencement of works (safety equipment and accessories) 9.7.2 Establishment of restricted area; posting and surveillance of restricted areas, 9.7.3 Use of time, distance, and shielding to reduce personnel radiation exposure, 9.7.4 Use of collimators to reduce personnel exposure 9.7.5 Use of "source changers" for gamma ray sources **9.8 Emergency procedures** 9.8.1 Equipment required during emergency 9.8.2 Emergency procedure involving x-ray equipment 9.8.3 Emergency procedure involving gamma ray source while in use (failure of source to return to safe shielded conditions, source detached from the device) 9.8.4. Emergency procedure involving gamma ray source while not in use (Vehicle	

	accidents with radioactive sealed sources; fire involving sealed sources, lost during transport, missing or stolen source) 9.9.5 Emergency call list **9.10 Regulations** 9.10.1 Regulatory authorities 9.10.2 Radioactive materials license requirements for industrial radiography 9.10.3 Qualification requirements for radiographic source shipment	accidents, fire involving sealed sources, lost during transport, missing or stolen source) 9.8.5 Emergency call list **9.9 Security of radiography source** 9.9.1 The need for security of radiography source 9.9.2. Categorization of radiography source 9.9.3 Security Level 9.9.4 Security function for Group B **9.10 Storage of gamma ray sources** 9.10.1 Long term storage 9.10.2 Temporary storage **9.11 Storage of x-ray machine** **9.12 Transport of radioactive materials** 9.12.1 Transport within company premises 9.12.2 Transport outside company premises 9.12.3 Packaging 9.12.4 Labelling 9.12.5 Receipt of gamma sources. **9.13 Disposal of gamma sources.** 9.14 Radiography accidents and reporting	

		9.14.1 Causes of accident 9.14.2 Some examples of radiography accidents**.** 9.14.3 Lessons learned from these accidents	
10. ADVANCE RADIOGRAPHY TECHNIQUES/SPECIAL APPLICATION		**(04 HRS)** **10.1 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)** **10.2 Neutron Radiography** 10.2.1 Basic Principle 10.2.2 Differences between neutron radiography and x- and gamma radiography 10.2.3 Application 10.2.4 Advantages and limitation **10.3 Introduction to Digital radiography** 10.3.1 Introduction to CR, DDA and fluoroscopy system 10.3.2 Film digitization 10.3.3 Portable computed tomography system 10.3.4 Advantages and limitation of digital radiography system	**(03 HRS)** **110.1 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)** **10.2 Neutron Radiography** **10.3 Computed tomography (3 Dimensional Imaging)** **10.4 Stereography Radiography** **10.5 Autoradiography** **10.6 Electron emission radiography** **10.7 In motion radiography** **10.8 Flash radiography** **10.9 Television radiography** **10.10 Xero radiography** **10.11. Radiography of concrete** construction 10.11.1 Standard related to radiography inspection of concrete

		10.4 Computed tomography (3-Dimensional Imaging) **10.5 Stereography Radiography** **10.6 Autoradiography** **10.7 Electron emission radiography** **10.8 In motion radiography** **10.9 Flash radiography** **10.10 Television radiography** **(04 HRS)** **10.11 Xero radiography**	10.11.2 Radiographic image of concrete internal structure **10.12 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)** **10.13 Application of radiographic techniques in non-conventional areas** 10.13.1 Aeronautics and aerospace 10.13.2 Offshore structures 10.13.3 Others
11. RECORDING AND - INTERPRETATION OF RESULTS-		**(03 HRS)** **11.1 Radiographic viewing** 11.1.1 Film-illuminator requirements, background lighting, multiple-composite viewing, dark adaptation and visual acuity 11.1.2 Film identification, location markers, IQI placement, IQI designation and visible hole/wire 11.1.3 Film-density measurement (application of film strip and densitometer) 11.1.4 Film artifacts	**(03 HRS)** **11.1 Comparison and application of imaging techniques including film, fluoroscopic and scintillation counting** **11.2 Treatment of the image including image analysis, enhancement, reconstruction, storage, transmission and evaluation** **11.3 Factors involved in valid interpretation of results**

		11.2 Radiographic evaluation 11.2.1 Evaluator/interpreter checklist 11.2.2 Evaluation of welds: welding method review; welding discontinuities; origin and typical orientation of discontinuities; radiographic appearance; welding codes/standards; applicable acceptance criteria; reference radiographs or pictograms 11.2.3 Evaluation of castings: casting method review; casting discontinuities; origin and typical orientation of discontinuities; radiographic appearance; casting codes/standards; applicable acceptance criteria; reference radiographs **11.3 Reporting test results** 11.3.1 Recording test results 11.3.2 Content of test report 11.3.3 Preparation of interim report 11.3.4 Preparation of full report and other documentation	

12. PRACTICAL	**12.1 Practical (22 HRS)** 12.1.1 Identification of types of radiation measuring equipment and applications 12.1.2 Handling of radiation equipment 12.1.3 Distinguish between types of films, screens filters and their applications 12.1.4 Carry out practical radiography work 12.1.5 Determination of density, sensitivity, and identification of relevant and non-relevant indications in radiographs 12.1.6 Training to follow guidelines in codes and standards	**(35 HRS)** **12.1 Instruction Writing** **12.2 Practical** 12.2.1 Same as level-I + Interpretation, evaluation of Radiographs, recording of test results and preparation of test reports 12.2.2 Identification of suitable techniques for various test pieces 12.2.3 Training to follow guidelines in codes and standards	**N/A**
TOTAL	58 HRS	94 HRS	80 HRS

Table 2 — Minimum training requirements

NDT method		Level 1 h	Level 2 h	Level 3 h
AT		40	64	48
ET		40	48	48
LT	B — Pressure method	24	32	32
	C — Tracer gas method	24	40	40
MT		16	24	32
PT		16	24	24
ST		16	24	20
TT		40	80	40
RT		40	80	40
UT		40	80	40
VT		16	24	24
NOTE For RT, training hours do not include radiation safety training.				

Method and Topic of the Lecture	Level 1	Level 2	Level 3
UT			
1. GENERAL KNOWLEDGE	**(1.1: 02 HRS & 1.2: 02 HRS)** **<u>1.1 INTRODUCTION –NDT</u>** 1.1.1 Definitions 1.1.2 Characteristics of NDT as a technology and Reasons for using NDT 1.1.3 Description and field of application of the Conventional NDT methods a) Visual testing b) Liquid penetrant testing c) Magnetic particle testing d) Radiographic testing e) Ultrasonic testing f) Eddy current testing g) Leak testing 1.1.4 Advantages and limitations in the common NDT methods 1.1.5 Responsibilities of personnel certified to level 1, 2 and 3 personnel **<u>1.2 INTRODUCTION - MATERIALS</u>** 1.2.1 Properties of materials (metal and non-metal) 1.2.2 Properties of metals 1.2.3 Discontinuities and defects	**(1.1: 03 HRS & 1.2: 06 HRS**) 1**.1BASIC PRINCIPLES OF NDT** 1.1.1 Definitions, physical principle and methodology of applications of basic NDT methods: VT, PT, MT, RT, UT, ET, LT 1.1.2 Area of application of common NDT methods 1.1.3 Advantages and limitations of common NDT methods 1.1.4 Other in NDT methods 1.1.5 Certification of NDT Personnel 1.1.6 Importance of quality control and quality assurance **1.2 INTRODUCTION-MATERIALS** 1.2.1 Structures of metals and alloys 1.2.2 Physical and mechanical properties of materials (metallic and non-metallic) 1.2.3 Discontinuities, defects and indications 1.2.4 Inherited, processing and In-service discontinuities	**(16 HRS)** **1.1 NDT METHODS, MATERIALS AND PROCESSES** 1.1 NDT methods- Basic knowledge of at least 4 NDT methods at level 2 1.1.1 Scope and limitations: comparison of different NDT methods 1.1.2 Selection of methods **1.2 Technology of materials** 1.2.1 Discontinuities and defects in materials. Classification according to location and morphology 1.2.2 Properties of materials 1.2.3 Nature of materials and solid state changes in materials 1.2.4 Phase Diagram and allotropy, ferrous metals 1.2.5 Non-ferrous metals and plastics 1.2.6 Nature of manufacturing 1.2.7 Casting process 1.2.8 Welding process 1.2.9 Rolling process 1.2.10 Forging process 1.2.11 Powder metallurgy 1.2.12 Machining fundamentals 1.2.13 Miscellaneous processes 1.2,14 Mechanism of in-service defect formation (corrosion, wear, tear,

	1.2.4 Primary processes and related defects a) Casting b) Welding c) Forging d) Rolling e) Heat treatment f) Machining g) Plating 1.2.5 In-service defects a) Overload b) Fatigue c) Corrosion d) Erosion e) Brittle fracture f) Others	1.2.5 Primary processes and inherited discontinuities 1.2.6 Metallurgical processes and discontinuities derived for them 1.2.7 Materials in service and discontinuities formed during in-service	fatigue crack, creep, hydrogen embrittlement, stress corrosion cracking, etc) 1.2.13 Surface finishing **(06 HRS)** **1.2. QUALITY ASSURANCE AND STANDARDIZATION** 1.2.1 Quality assurance 1.2.1.1 Basic principles for the application of quality assurance 1.2.1.2 Organization of quality assurance, Quality manual, Quality control, Auditing of Quality 1.2.1.3 Management and control of quality assurance documentation, quality control of testing 1.2.1.4 Certification and accreditation of NDT facilities 1.2.1.5 Reports on testing, documentation systems 1.2.2 Standardization 1.2.2.1 Definition of standardization, principles for writing of standards 1.2.2.2 Codes, standards, specification procedures and instructions 1.2.2.3 Procedure Writing, i.e format, structure, and content of procedures 1.2.2.4 Procedure validation 1.2.3 Reports and protocols

			(04 HRS) **1.3 ORGANIZATION AND ADMINISTRATION OF NDT** 1.3.1 Organization and administration of NDT 1.3.1.1 Safety: a) Implementation of industrial safety standards in facilities and equipment and in their operation b) Hazards of using toxic and inflammable materials c) Materials, accessories and equipment, for the protection of persons and facilities 3.1.2 Organization a) Organization structure of NDT Department or NDT organization b) Equipment for work under way; Logistic provisions c) Testing on production lines; Flow of materials; Work shifts d) Maintenance of equipment and facilities 1.3.1.3 Costs a) Investments in equipment b) Direct and indirect staff costs c) Calculation and analysis of costs and profitability

			1.3.1.4 Equipment selection and facility design 1.3.1.5 Operating procedures and record keeping **(04 HRS)** **1.4. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL** 1.4.1 Training, Qualification and Certification of NDT personnel 1.4.1.1 National standards for the qualification and certification of personnel. 1.4.1.2 Regional and international recommendations, e.g ISO 9712 1.4.1.3 Organization of courses and training in NDT methods 1.4.1.4 Code of ethics **(10HRS)** **1.5. REVISION OF FOUR MAIN NDT METHODS**
2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS	**(06 HRS)** **2.1 General concepts** 2.1.1 Definition of ultrasonic 2.1.2 History of ultrasonic testing 2.1.3 Applications of ultrasonic energy 2.1.4 Properties of sound and propagation of mechanical waves	**(06 HRS)** **2.1 The nature of ultrasonic waves** **2.2 Characteristics of wave propagation** 2.2.1 Frequency 2.2.2 Amplitude	**(05 HRS)** **2.1 Nature of ultrasonic waves** **2.2 Characteristics of ultrasonic wave propagation: frequency, wavelength, velocity, acoustic impedance, acoustic energy, acoustic intensity, amplitude.**

	2.2 Concepts relating to frequency, amplitude, wave length and speed of propagation **2.3 Acoustic impedance** **2.4 Influence of wave type on the test method** 2.4.1 Longitudinal waves and transverse waves 2.4.2 Surface waves and Lamb waves **2.5 Reflection and refraction** 2.5.1 Modes conversion 2.5.2 Attenuation 2.5.3 Snell's law and critical angles **2.6 Ultrasonic wave transfer from one medium to another** 2.6.1 Generation of ultrasonic waves 2.6.2 Ultrasonic losses in different media **2.7 Piezoelectric effect, characteristics and types of crystals, piezoelectric constants** **2.8 Sonic field influence of speed of sound and transducer size** **2.9 Types of transducers; normal; emitter-receiver; angular** **2.10 Influence of transducer's frequency and diameter (add)** **2.11 The sonic path; near field; far field; beam divergence** **2.12 Couplant**	2.2.3 Wave length 2.2.4 Velocity 2.2.5 Acoustic impedance 2.2.6 Acoustic pressure 2.2.7 Acoustic energy 2.2.8 Acoustic intensity **2.3 Types of ultrasonic waves and their applications** 2.3.1 Longitudinal wave 2.3.2 Transverse wave 2.3.3 Surface wave 2.3.4 Extensive knowledge of Rayleigh and Lamb waves **2.4 Behavior of ultrasonic waves: normal incidence; angular incidence; reflection and refraction; mode conversion** **2.5 Transfer of energy from one medium to another** 2.5.1 Generation of ultrasonic waves 2.5.2 Energy losses in various media **2.6 Piezoelectric and magneto restrictive effect on the crystal** **2.7 Characteristics of the sound beam** 2.7.1 Far field and near field 2.7.2 Influence of sound velocity and transducer size	**2.3 Types of ultrasonic waves and their applications:** 2.3.1 Longitudinal wave 2.3.2 Transverse wave 2.3.3 Surface wave 2.3.4 Lamb wave 2.4 Behavior of ultrasonic waves 2.4.1 Normal incidence 2.4.2 Angular incidence 2.4.3 Reflection and refraction 2.4.4 Methods of mode conversion 2.4.5 Snell's law 2.4.6 Modes of sound wave propagation

		2.7.3 Field divergence 2.8 Attenuation of sound: Cause and effect; principles of measurement of attenuation	
3. TESTING TECHNIQUES AND THEIR LIMITATIONS	**(03 HRS)** **3.1 Pulse- echo technique:** 3.1.1 By direct contact 3.1.2 Immersion a) Transducers in water b) Water column, wheels c) Submerged test part d) Sound-beam path - transducer to water path length e) Focused transducers f) Curved surfaces g) Comparison of contact and immersion methods 3.1.3 Pitch catch transducers **3.2 Transmission technique** **3.3 Resonance technique** **3.4 Methods of coupling** **3.5 Testing with automatic systems and on the production line**	**(06 HRS)** **3.1 Test methods: transmission method; pulse- echo method; resonance method; automatic and semi- automatic methods** **3.2 Transducers: normal incidence angular incidence transducers; special transducers** **3.3 Techniques: tandem techniques; focused transducers technique; double-crystal transducers technique; surface-wave transducers technique; immersion techniques** **3.4 Limitations in the application of the ultrasonic test method** **3.5 Defect sizing techniques: maximum amplitude; 6db drop; 20db drop; distance gain size (DGS)** **3.6 Discontinuity detection:** 3.6.1 Sensitivity to reflections 3.6.2 Resolution	**(05 HRS)** **3.1 Testing methods:** 3.1.1 Transmission method 3.1.2 Pulse-echo method 3.1.3 Resonance method 3.1.4 Automatic and semi- automatic methods a) Time of flight diffraction b) Phased array c) C scan (Portable C scan) d) Guided wave e) Corrosion Mapping (T scan) **3.2 Transducers:** 3.2.1 Normal -incidence transducers 3.2.2 Angular- incidence transducers 3.2.3 Special transducers **3.3 Techniques:** 3.3.1 Tandem technique 3.3.2 Focalized transducers technique 3.3.3 Double crystal technique 3.3.4 Surface -wave transducers technique 3.3.5 EMAT transducers

		3.6.3 Determination of discontinuity size 3.6.4 Location of discontinuity **3.7 Setting test sensitivity** 3.7.1 Distance amplitude correction (DAC) 3.7.2 DGS 3.7.3 Attenuation and transfer correction. Beam divergence factor **3.8 Echo classification systems: pattern responses, planar defects; volumetric defects; discrete reflectors; diffuse reflectors**	3.3.6 Multi probe arrays 3.3.7 Immersion techniques a) Transducer in water b) Water column, wheels etc c) Submerged test part d) Sound beam path — transducer to part e) Testing of curved surfaces **3.4 Limitations to the application of ultrasonic testing** **3.5 Preparation of Written Producers**
4. EQUIPMENT AND ACCESSORIES	**(02 HRS)** **4.1 Description of the basic testing equipment with display of the information in a representation (A-scan)** **4.2 Basic B-C scan and computerized systems** **4.3 Analog and digital equipment for thickness measurements** **4.4 Controls and Functions** 4.4.1 Functions 4.4.2 Use 4.4.3 Recorders 4.4.4 Alarms 4.4.5 Automatic and semi-automatic systems	**(03 HRS)** **4.1 Construction and mode of operation of ultrasonic equipment** 4.1.1 Functions of the electronic elements in a typical instrument 4.1.2 Types of instrumentation: a) portable b) laboratory (statutory) c) Digital d) Automated and semi-automated systems and Characteristics of equipment and system controls **4.2 Characteristics of equipment and system controls** 4.2.1 Properties of vertical and horizontal amplifiers	**(06 HRS)** **4.1 Construction and mode of operation of ultrasonic equipment** 4.1.1 Functions of the electronic elements in a typical instrument 4.1.2 Types of equipment: a) portable b) laboratory (statutory) c) digital d) automated installations **4.2 Characteristics of equipment and system controls** 4.2.1 Properties of vertical and horizontal amplifiers 4.2.2 Correlation between resolving power and frequency, transmitting power, damping

	4.4.6 Electronic distance/amplitude correction 4.4.7 Transducers - structure, types of crystals, frequency (crystal thickness relationships) 4.4.8 Beam spread 4.4.9 Sensitivity, resolution and damping 4.4.10 Couplants	4.2.2 Correlation between resolving power and frequency, transmitting power, damping 4.2.3 Linearity 4.2.4 Saturation and amplifier threshold **4.3 Signal presentation: echo amplitude and its control; more in-depth knowledge on A scan; B-scan; C-scan; correlation of digital and analogue signals** **4.4 Recording instrumentation** 4.4.1 Automatic monitors 4.4.2 Computer interfacing 4.4.3 Recorders, printers and color markers	4.2.3 Linearity 4.2.4 Saturation and amplifier threshold **4.3 Signal presentation: Echo amplitude and its control; A-scan; B-scan; C-scan; P-scan; T-scan; correlation of digital and analogue signals** **4.4 Recording instrumentation** 4.4.1 Automatic monitors 4.4.2 Computer interfacing 4.4.3 Recorders, printers and color markers
5. CALIBRATION OF THE TESTING SYSTEM	**(04 HRS)** **5.1 Distance calibration for normal single and double crystal transducers (transmitter/ receiver)** **5.2 Angular transducers of transverse waves** 5.2.1 Sonic path calibration (distance, angle) 5.2.2 Projected distance, pulse echo variables, transmission factors 5.2.3 Shortened projected distance **5.3 Checking the calibration: consideration of differences in speed of propagation between calibration**	**(06 HRS)** **5.1 Calibration of equipment** 5.1.1 Horizontal linearity 5.1.2 Vertical linearity **5.2 Verification of the sensor** 5.2.1 Calibration blocks Vl andV2 5.2.2 Sensor sensitivity 5.2.3 Sensor resolution 5.2.4 Verification of an angular sensor **5.3 Calibration in curved work pieces** **5.4 Construction of distance-amplitude correction (DAC)**	**(03 HRS)** **5.1 Calibration and adjustment of the equipment:** 5.1.1 Calibration of equipment electronics a) Variable effects b) Transmission accuracy 5.1.2 Accessories 5.1.3 Control of calibration **5.2 Calibration of the sensitivity of the test, different geometric conditions** 5.2.1 Reference reflectors for calibration

	block and test piece, comparison with reference blocks **5.4 Variable effects, transmission accuracy** **5.5 Calibration requirements and reflectors** **5.6 Inspection calibration**	**5.5 DGS method** **5.6 Sizing techniques, principles and limitations** **5.7 Coupling medium**	a) Balls, side drilled and flat bottomed holes b) Area amplitude blocks c) Distance amplitude blocks d) Notches e) Special blocks, I.I.W and others 5.2.2 Design and preparation of calibration units 5.2.3 Various calibration criteria (D.A.C., D.G.S., etc.) and selection of suitable reflectors 5.2.4 Exact measurement of speed of propagation, use of interferometers **5.3 Transmission of ultrasonic energy across the surface being explored** 5.3.1 Condition of surface, curvature 5.3.2 Precautions against excitation 5.3.3 Crystal diameter and coupling medium 5.3.4 Connecting cables: insulation, flexibility, contact pins
6. SPECIFIC APPLICATIONS	**(03 HRS)** **6.1 Testing of specimens of simple geometries** 6.1.1 Examination of sheets 6.1.2 Examination of billets 6.1.3 Examination of castings **6.2 Thickness measurements** 6.2.1 Influence of material type	**(06 HRS)** **6.1 Methods of examination** 6.1.1 Cast work pieces 6.1.2 Welded work pieces 6.1.3 Components and systems 6.1.4 Austenitic materials 6.1.5 Forged work pieces	**(04 HRS)** **6.1 Methods of examination** 6.1.1 Cast work pieces 6.1.4 Welded work pieces 6.1.5 Components and systems 6.1.4 Austenitic materials 6.1.5 Forged work pieces

	6.2.2 Influence of surface condition **6.3 Influence of geometry and structure** **6.4 Detection of corrosion**	6.1.6 Non-metallic materials (ceramics, plastics, etc.) 6.1.7 Bonded structures	6.1.8 Non-metallic materials (ceramics, plastics, etc.) 6.1.9 Bonded structures
7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	**(03 HRS)** **7.1 General knowledge** **7.2 Codes and standards** **7.3 Performance of tests in accordance with written instructions, selection of parameters** **7.4 Recording of results** **7.5 Preparation of test reports**	**(7.1& 7.2: 06 HRS)** **7.1 Codes, standards and specifications specifically related to ultrasonic testing** **7.2 Testing procedures:** 7.2.1 Selection and verifications of equipment 7.2.2 Position and direction of scan 7.2.3 Calibration 7.2.4 Comparison procedures a) Standards and references b) Amplitude area and distance relationship c) Application of results of other NDT methods 7.2.5 Object appraisal a) History of part b) Geometry of part c) Intended use of part d) Interpretation to code/specification e) Type and location of discontinuity	**(7.1-7.3: 06 HRS & 7.4: 03HRS)** **7.1 Examination specifications** 7.1.1 Function of design engineering 7.1.2 Design and building codes 7.1.3 ASME Code **7.2 Standards for ultrasonic testing** 7.2.1 Specific standards for testing with ultrasonic (ASTM, JIS, EN) 7.2.2 Interpretation of specifications, codes and standards **7.3 Test procedures** 7.3.1 Drafting of test procedures 7.3.2 General and specific procedures, Specific applications to be considered a) Detection of flaws b) Thickness assessment c) Bond evaluation d) Fluid flow measurements e) Material properties measurements f) Computer control and defect analysis g) Liquid level setting h) Process control i) Field inspection 7.3.3 Safety and health consideration: electric shock; mechanical hazards;

			pneumatic hazards; chemical contamination **7.4 Procedure Writing**

8. RECORDING AND EVALUATION OF RESULTS	**(03 HRS)** **8.1 Recording of the test results** 8.1.1 Position of defects 8.1.2 Echo amplitude 8.1.3 Acceptance levels	**(06 HRS)** **8.1 Response of the equipment to various types of defects** **8.2 Interpretation of relevant codes and standards** **8.3 Evaluation of discontinuities in accordance with specifications, standards and codes** **8.4 Recording and reporting the results of a test, storage of records, traceability**	**(02 HRS)** **8.1 Response of the equipment to the various types of defect** **8.2 Evaluation of discontinuities, in accordance with specifications, standards and codes** **8.3 Development of acceptance criteria into written procedures** **8.4 Recording and reporting on the test**

9. SPECIAL TECHNIQUES	**N/A**	**(03 HRS)** **9.1 Special inspection problems and techniques used to solve them** **9.2 Automated and semi-automated testing techniques** **9.3 Special techniques for data processing** **9.4 Time of flight diffraction, ToFD** **9.5 Automatic UT (P scan)** **9.6 Phased array** **9.7 C scan (portable C scan)** **9.8 Corrosion mapping and detection (T scan)** **9.9 Guided waves**	**(06 HRS)** **9.1 Special techniques** 9.1.1 Ultrasonic holography 9.1.2 Ultrasonic spectroscopy 9.1.3 Time of Flight Diffraction, ToFD 9.1.4 Phase Array 9.1.5 Automated and semi- automated testing techniques 9.1.6 Special techniques for data processing
10. PRACTICAL	**10.1 Practical (26 HRS)** 10.1.1 Recognize each of the controls and its function of UT Machine 10.1.2 Perform the calibration correctly at a distance with normal sensors 10.1.3 Testing of specimens of simple geometries 10.1.4 Thickness measurements 10.1.5 Identification of relevant and non-relevant indications 10.1.6 Locating the flaw and Size Estimation Techniques	**(39 HRS)** **10.1 Instruction Writing** **10.2 Practical** 10.2.1 Same as level-I + Interpretation, evaluation, and preparation of test reports 10.2.2 Perform the calculation for obtaining the angle of incidence 10.2.3 Test the horizontal and vertical linearity of the equipment 10.2.4 Test the sensor to determine its sensitivity and resolution	**N/A**

	10.1.7 Recording the results of the test with respect to the position and size of the reflector 10.1.8 Training to follow guidelines in codes and standards	10.2.5 Perform calibration using curved work pieces 10.2.6 Construction of distance-amplitude correction (DAC) 10.2.7 Recognize and evaluate discontinuities in accordance with a specific code 10.2.8 Record the results of the test in proper format 10.2.9 Training to follow guidelines in codes and standards	
TOTAL	**54 HRS**	**90 HRS**	**80 HRS**

Table 2 — Minimum training requirements

NDT method		Level 1 h	Level 2 h	Level 3 h
AT		40	64	48
ET		40	48	48
LT	B — Pressure method	24	32	32
	C — Tracer gas method	24	40	40
MT		16	24	32
PT		16	24	24
ST		16	24	20
TT		40	80	40
RT		40	80	40
UT		40	80	40
VT		16	24	24
NOTE For RT, training hours do not include radiation safety training.				

Minimum equipment holdings for NCBNDT Approved Training Organizations (ATOs)

1. SCOPE

This document prescribes the minimum equipment holdings essential for the operation of a training organisation preparing candidates. This details the minimum equipment for the following NDT methods.

I. Ultrasonic testing
II. Radiography Testing
III. Digital Radiography
IV. Eddy current testing
V. Magnetic particle inspection (multi-sector)
VI. Liquid penetrant inspection (multi-sector)

2. Ultrasonic testing

2.1 Sufficient ultrasonic flaw detectors (based on perceived maximum class size)
2.2 A full range of probes appropriate to the techniques to be trained, including any special purpose probes where required
2.3 Calibration blocks and reference blocks appropriate to test
2.4 Couplant

Guidance Note: Where necessary the equipment may be loaned/hired by the equipment manufacturer or employer of students for use during training

3. Radiography

3.1 At least one X-ray tube with a kV range appropriate to the materials to be tested
3.2 For gamma radiography (where appropriate) an appropriate source, with suitable container and projection mechanism
3.3 Suitably controlled exposure rooms or areas
3.4 An X-ray beam controlling device
3.5 Supply of appropriate radiographic film and processing chemicals
3.6 A range of image quality indicators (IQI)
3.7 Lead letters and numbers
3.8 Blocking off compounds and liquids where appropriate
3.9 Copper (Cu) and Lead (Pb) filters where appropriate
3.10 Densitometer
3.11 Film viewers, including at least one high-intensity viewer
3.12 Radiation monitor
3.13 Stepped blocks for making exposure curves
3.14 Caliper or other device for measuring material thickness
3.15 Darkrooms for film processing and film preparation
3.16 Viewing aids, such as magnifiers

3.17 A manual and/or automatic processing unit incorporating thermostatically controlled developing tank, stop bath, rinsing, fixing and washing tanks
3.18 Film drying cabinet
3.19 Channel and clip type film hangers in the common sizes
3.20 lead screens in the common sizes/materials
3.21 Flexible and rigid type cassettes
3.22 Darkroom timer (for manual processing only)
3.23 Safelights
3.24 Thermometer

4. Digital Radiography

4.1 Suitable radiation-generating equipment appropriate to the materials to be tested
4.2 Suitably controlled exposure rooms or areas
4.3 DR/CR/DDA system or systems (appropriate to training delivered)
4.4 X-ray image intensifier(Image Plate) or DDA
4.5 High-definition monitors for image viewing
4.6 Suitable computer systems for student use – with compatible image processing software
4.7 Tool(s) for quality control checking of linearity, grey scale, pixel values, etc
4.8 Simulation files – for data manipulation and interpretation training

5. Eddy Current Testing

5.1 At least one standard single-frequency impedance plane instrument and one analogue meter display instrument or a corresponding digital version.
5.2 Where training incorporates bolt hole testing, one dynamic rotating probe assembly and compatible instrument where appropriate
5.3 Absolute and differentially wound standard and shielded pencil and spade probes, suitable for testing ferritic and austenitic steels and aluminium alloys
5.4 A selection of encircling, internal, bolt hole and comparative coil types
5.5 Calibration blocks, appropriate to all probe and material types

6. Magnetic Particle Testing (multi-sector)

6.1 A bench or freestanding transformer with AC or DC output (and half wave rectified AC) with the capability to magnetize test specimens in the appropriate manner. The maximum output shall be capable of testing the range of components to be tested
6.2 AC/DC electromagnetic yokes with articulated legs and pole pieces
6.3 Permanent magnets with pole piece adaptors suitable for all applications
6.4 Various rigid and flexible coils, threading bars, etc
6.5 Inspection areas or booths equipped with suitable background lighting for visible and UV (A) viewing of samples
6.6 Independent or combined lux meter and black light meter for measuring the intensity of visible and black light
6.7 Demagnetising equipment
6.8 A Flux measuring and comparison gauges to standard recommendations
6.9 Sutherland flask or Crowe receiver for measuring solid content of magnetic ink
6.10 Dry powder dispensers
6.11 Supplies of detection media including non-fluorescent, fluorescent and dry powder
6.12 Artificially or naturally cracked blocks/specimens for performance checking

7. Liquid Penetrant Testing (multi-sector)

7.1 An effective component cleaning/degreasing facility for thorough cleaning of specimens
7.2 Water-washable penetrant tank
7.3 Post-emulsifiable penetrant tank
7.4 Emulsifier tank
7.5 Water rinsing station with spray nozzle
7.6 Drying station
7.7 Dust storm cabinet
7.8 Aerosol liquid penetrant inspection kits comprising:
7.9 Penetrant remover/degreaser
7.10 Fluorescent penetrant
7.11 Colour contrast penetrant
7.12 Developer
7.13 Inspection areas or booths equipped with suitable background lighting for visible and UV (A) viewing of samples
7.14 Independent or combined lux meter and black light meter for measuring the intensity of visible and black light
7.15 Artificial flaws (TAM panel) or other means of process control of penetrant line

National Certification Body for Non Destructive Testing, Sri Lanka (CBNDT - Sri Lanka)

Examination Guidelines

1. Conduct of the Qualification Examination

1.1. All candidates shall fulfill the following requirements before the qualification examination.

1.1.1 Comply with the minimum requirements for the training course;
(**Note**: The attendance of the training course concerning the minimum training requirements as per ISO 9712:2012 before the qualification examination will be checked.)

1.1.2 Meet the minimum requirements on the vision;

1.2. All candidates shall sit for all parts of the examination at the original qualification examination.

1.3. Candidates are required to submit the completed "Examination Application Form" along with the "Eye Examination Report" to the Management Assistant (MA) of Examination Committee (EC) of CBNDT at least 03days before commencing the qualification examination.

1.4. Candidates shall collect the "Examination Agreement" and "Examination Admission" before the qualification examination from the MA of EC of CBNDT.

1.5. Candidates shall bring their national identity card/passport, "Examination Admission", and the signed "Examination Agreement" into the examination hall.

1.6. Candidates shall present in the examination hall 05 minutes before the commencement of the examination.

1.7. Candidates are not allowed to admit to the examination hall (for any reason whatsoever) after the expiry of half an hour from the commencement of the examination.

1.8. No candidate is allowed to leave the examination hall until 45 minutes have elapsed since the commencement of the examination or during the last 10 minutes of the examination.

1.9. Candidates shall use a blue or black colored ink pen to write or mark the answers.

1.10. If you wish to make any amendment for an already marked answer, you shall put your signature there.

1.11. Candidates who finish early are allowed to hand over their answer scripts to the Examiner/Invigilator and leave the examination hall without disturbing the other candidates.

1.12. After the examination, all candidates must remain seated until the answer scripts have been collected and the Examiner announces them to leave the examination hall.

2. Content of the Qualification Examination

2.1 Level 1 and Level 2: General Examination, Specific Examination, and Practical Examination
(Note: There is an additional examination on Radiation Safety for the Radiographic Testing (RT) in both Levels)

2.2 Level 3: Basic Examination - Parts A, B, and C and Main Method Examination - Parts D, E, and F.
(Note: Level 3 candidates shall have completed (with a grade of ≥ 70%) the practical examination for Level 2 in the relevant sector and method, except for the drafting of Non Destructive Testing (NDT) Instruction Writing for Level 1)

Note:

1. For Level 1 Practical Examination there is only one Section i.e. practical.
2. For Level 2 Practical Examination there are two Sections i.e. Section 1- Practical, and Section 2 – NDT Instruction Writing
3. General, Specific, Radiation Safety, Basic, and Main Method Examinations are written examinations.
4. Copies of relevant codes/standards are given for the Specific Examination and Practical Examination.
5. With the approval of the certification body, a candidate for a practical examination may use his equipment.

3. Evaluation of Results

3.1. The overall result of the examination is "Pass" (P) or "Refer" (R) or "Fail" (F).

3.2. To be eligible for certification, the candidate shall obtain a minimum grade of 70% in each part of the examination.

3.3. Also, for the practical examination, a minimum grade of 70% shall be obtained each specimen tested, and for the NDT Instruction Writing, as applicable.

3.4. The results of each candidate will be informed through a letter by the Chairman of EC of CBNDT.

3.5. A qualification certificate will be issued within 90 days after the examination to each candidate, who has completed the examination successfully.

3.6. It is the responsibility of candidates to apply for the certification within two years period of the qualification examination date and otherwise, he/she has to re-sit for the practical examination in the relevant sector, method, and Level to re-qualify.
(Note: Level 2 practical examination is except for the drafting of NDT Instruction Writing)

National Certification Body for Non Destructive Testing, Sri Lanka (CBNDT - Sri Lanka)

Examination Guidelines

4. Re-examinations

4.1 A candidate who is unable to obtain the passing grade for any examination part, maybe re-examined twice (02) in the referred parts, provided that the re-examination takes place not sooner than one (01) month unless further training acceptable to the certification body is satisfactorily completed, nor later than two (02) years after the original examination.

4.2 A candidate who is unable to pass all permitted re-examinations shall apply for and take the examination following the procedure established for new candidates.

5. Re-certification

5.1 If the re-certification is applied for more than twelve (12) months after the expiry of the period of validity of certification a complete examination (General, Specific, and Practical) for Level 1 and Level 2 and the Main Method Examination for Level 3 shall again be passed successfully.

5.2 For Level 1 and Level 2

5.2.1 If the re-certification is applied before the expiry of the period of validity of certification or within twelve (12) months after the expiry of the period of validity, the individual shall complete a practical examination which demonstrates continued competence to carry out work within the scope defined on the certification certificate.

5.2.2 This shall include testing specimens appropriate to the scope of certification to be revalidated and besides, for Level 2, the production of a written instruction suitable for the use of Level 1 personnel.

5.2.3 If the individual is unable to achieve a grade of at least 70% for each specimen tested, and, for Level 2, for the Instruction Writing, two retests of the whole recertification examination shall be allowed after at least seven (7) days and within six (6) months of the first attempt at the re-certification examination.

5.2.4 In the event of a failure in the two allowable retests, the certificate shall not be revalidated and, to regain certification for that Level, sector, and method, the candidate shall apply for a new certification.

5.3 For Level 3

5.3.1 The individual may decide between the Written Examination/Structured Credit System for re-certification.

5.3.2 In the Written Examination, the individual shall either provide appropriate documented evidence, acceptable to the CBDNT, of his/her continued practical competence in the method or pass a Level 2 practical examination, except for the drafting of NDT instructions.

5.3.3 In the Structured Credit System, the individual shall pass a Level 2 practical examination, except for the drafting of NDT instructions.

5.3.4 The Written Examination consists of a minimum of 20 questions as per the defined scope of 11.3.2 of ISO 9712:2012.

5.3.5 If the individual is unable to achieve a grade of at least 70% in the recertification examination, a maximum of two retests shall be allowed. The period within which all tests are to be taken shall be twelve (12) months unless otherwise extended by the CBNDT.
In the event of a failure in the two allowable retests, the certificate shall not be revalidated, and, to regain certification for that sector and method the candidate shall be required to achieve success in the appropriate Main Method Examination.

5.3.6 A candidate who applies for and does not meet the requirements of the Structured Credit System shall be re-certified in accordance with 11.3.2 of ISO 9712:2012.
In the event of a failure at the first attempt at re-certification by examination, only one retest of the re-certification examination shall be allowed within twelve (12) months of the date of application for re-certification via the Structured Credit System.

6. Absence in Examinations

6.1 A candidate unable to attend for the complete or part of the original qualification examination for any reason (medical/other) is considered as not completed the examination and shall complete the full qualification examination within the next two attempts.

6.2 A candidate unable to attend for the complete or part of the 1st re-examination for any reason (medical/other) is considered as not completed the 1st re-examination and shall complete the full examination within the next attempt.

6.3 A candidate unable to attend for the complete or part of the 2nd re-examination for any reason (medical/other) is considered as not completed the 2nd re-examination and shall complete the full examination as a new candidate.

7. Reference Documents

7.1 ISO 9712:2012 – Non-destructive testing - Qualification and certification of NDT personnel

7.2 CBNDT/SOP/06:Revision 2 – Procedure for NDT Examinations

T M R Tennakoon
Director General
Sri Lanka Atomic Energy Board

Approved.
03/09/2020

Appendix 10

	Title: Format of the Certification Certificate		
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CERTIFICATION BODY FOR
NON DESTRUCTIVE TESTING PERSONNEL
Sri Lanka

ISO/IEC 17024
BP 001-01

Name of the certified holder

is certified in

NON DESTRUCTIVE TESTING

Method and Level

in accordance with the requirements of
"ISO 9712:2012, Non-destructive testing-qualification and certification of personnel".

Industrial Sector:
Product Sector :

Date Issued

Valid Until

Certificate Number

Personnel Identification Number

.....
Signature of Certified Individual

Chairman,
Sri Lanka Atomic Energy Board &
National Certification Body for NDT

Agreement of Certified Individual with NCBNDT - Sri Lanka

This agreement is made and entered into as of ……..…..... 20…... by and between the certification Body for Non Destructive Testing (CBNDT) and the Certified Individual.

Certified persons shall:

- Accept obligations only for the areas of work for which you are competent and certified;
- Comply with the relevant provisions of the certification scheme;
- Maintain the integrity and high standard of skills and practices in the profession of NDT at all times;
- Undertake only those non-destructive testing assignments for which are competent by virtue of training, experience, qualification and certification;
- Make claims regarding certification only with respect to the scope for which certification has been granted;
- Be responsible for all work carried out by you or others under your supervision and control;
- Not use the certificate in a misleading manner;
- Reject any task which he/she cannot perform professionally;
- Be responsible to safeguard the life, health, property, and welfare of the public at all times and for the laws and statutory regulations;
- Associate with or permit to use skills and knowledge in the interest of the employer or client to whom they work in a truthful manner to the best of your ability;
- Not use the certification in such manner as to bring the CBNDT into disrepute, and not make any statement regarding the certification which may be considered misleading or unauthorized;
- Provide professional advice, express opinions and make statements on the basis of adequate knowledge in truthful manner;
- Sign documents with personal professional knowledge and/or direct supervisory control only;
- Be objective during NDT report writing, and shall not sign any documents without reading them carefully;
- Be responsible for updating the current profile and NDT experience by reporting activities to the CBNDT;
- Undergo an annual test of visual acuity, and submit the results of the tests to the employer;
- Notify CBNDT and the employer in the event that the conditions for validity of certification are not fulfilled;
- Inform CBNDT without delay, of matter that can affect the capability of the certified person to continue to fulfill the certification requirements;
- Discontinue the use of all claims to certification that contain any reference to the CBNDT or to certification upon expiry, suspension or withdrawal of certification, and upon request return any certificate(s) issued by the certification board;
- Inform the employer in the event that the certification is suspended, cancelled or withdrawn;
- Inform CBNDT regarding any change of residence, working place, working area and contact information;
- Immediately report to CBNDT any perceived violation(s) of codes, regulations or standards;
- Immediately report to CBNDT any attempt to pressure or force an individual certified to violate the code of ethics.

The certification becomes invalid:

a) At the discretion of the CBNDT, e.g. after reviewing evidence of behavior incompatible with the certification procedures or failure to abide by the code of ethics;

b) If the individual becomes physically incapable of performing his duties based upon failure of the visual acuity examination taken annually under the responsibility of his employer;

c) If a significant interruption takes place in the method for which the individual is certified;

[significant interruption - absence or change of activity which prevents the certified individual from practicing the duties corresponding to the level in the method and the sector(s) within the certified scope , for either a continuous period in excess of one year or two or more periods for a total time exceeding two years.]

d) If the individual fails recertification, until such time as the individual meets the requirements for recertification or initial certification.

The certification will be suspended:

- If the certified person is physically unable to carry out their tasks, based on not providing the annual vision acuity validation to his/her employer;
- If a significant interruption (one year break) occurs in the industrial practice of the certified person;
- If the certified person fails to meet the requirements of the recertification;
- In situations where inappropriate reference to the certification or misleading use of certificates/ marks/ logos in publications/ catalogues is done;
- Any noncompliance of a certificate holder according to the code of ethics established by CBNDT.

Failure to resolve the issues that have resulted in suspension, in the time established by the CBNDT will be subjected to be withdrawn the certification.

I am aware that:

- Improper conduct, malpractice and ruling of other jurisdictions may result in recommended disciplinary action by the CBNDT.
- Any misuse of CBNDT logo is prohibited and will be punished.
- Failure to comply with the code of ethics will be dealt with under arrangements for handling complaints and appeals and may necessitate corrective measures, such as the termination of the certification process, the suspension or withdrawal of certification, publication of the violation, notification of the employer(s), union(s) and appropriate regulatory authorities and, if appropriate, additional legal action.

…… ……..

Name of Certified Individual Signature

The CBNDT agrees to the following:

- Information obtained during the certification process, or from sources other than the applicant, candidate or certified persons, is not disclosed to an unauthorized party without the written consent of the individual (applicant, candidate or certified person), except where the law requires such information to be disclosed.
- When the CBNDT is required by law to release confidential information, the person concerned will be notified (unless prohibited by law) as to what information will be provided.

…… ……..

Name of CB Representative Signature

Training Specimen

1. Welds

Courses leading to certification examinations in NDT of welds shall include, as a minimum, samples exhibiting the following discontinuities.

1.1 Excessive root penetration
1.2 Incomplete root penetration
1.3 Heat-affected zone cracking
1.4 Sidewall slag inclusion
1.5 Lack of sidewall fusion
1.6 Central crack in weld
1.7 Transverse crack in weld
1.8 Porosity (localized and uniform)
1.9 Lack of root fusion
1.10 Solidification cracking
1.11 Lamellar tearing
1.12 Worm holes
1.13 Tungsten/copper inclusions

2. Castings

Courses leading to certification examinations in casting are required to have, as a minimum, samples showing the following.

2.1 Gas porosity

2.2 porosity

2.3 Core blows

2.4 Misruns

2.5 Cold shuts

2.6 Shrink porosity

2.7 Hot tears

2.8 Core shifts

2.9 Segregation

2.10 Inclusions

2.11 Cracking

2.12 Sponginess

2.13 Air locks

2.14 Shrinkage defects (cavities/filamentary/dendritic, etc)

2.15 Diffraction mottling

3. Wrought Products

Courses leading to certification examinations in wrought products are required to have, as a minimum, samples showing the following.

3.1 Rolled products:

3.1.1 Rolling laps
3.1.2 Broken or burst corners
3.1.3 Inclusions
3.1.4 Piping

3.2 Forgings:

3.2.1 Forging burst
3.2.2 Forging laps
3.2.3 Forging flash
3.2.4 Hydrogen cracking
3.2.5 Voids

3.3 Incorrect heat treatment:

3.3.1 Reheating cracks
3.3.2 Cooling cracks
3.3.3 Machining defects
3.3.4 Grinding cracks
3.3.5 Surface tearing

3.4 Service Crack

3.4.1 Fatigue Crack
3.4.2 Stress Crack

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Structured credit system for Level 3 recertification

Item	Activity	Point accorded for each item (or function)	Maximum points per year per item	Maximum point per 5 year period per item
1	Membership of an NDT society, attendance at seminars, symposia, conferences and/or course covering NDT and related sciences and technologies	1	3	8[a]
2.1	Attendance at international and national standardization committees	1	3	8[a]
2.2	convenorship of standardization committees	1	3	8[ab]
3.1	Attendance at sessions of the other NDT committees	1	3	8[a]
3.2	convenorship of sessions of the other NDT committees	1	3	8[ab]
4.1	Attendance at Sessions of NDT related working group	1	5	15[a]
4.2	convenorship of NDT related working group	1	5	15[ab]
5.1	NDT related technical/scientific contribution or publications	3	6	20[cd]
5.2	NDT related research work published	3	6	15[cd]
5.3	NDT research activity	3	6	15[cd]
6	NDT technical instructor (per 2h) and/or NDT examiner (per examination)	1	10	30[d]
7	Professional activity	-	-	-
7.1	within a NDT facility, NDT training center or NDT examination facility or for Engineering of NDT (See Annex E of ISO 9712:2012) (for each full year)	10	10	40[d]
7.2	Dealing with disputes referring to clients	1	5	15[d]
7.3	Development of NDT applications	1	5	15[d]

a Maximum points for item 1 to 4: 20
b point to be given for both convenorship and attendance
c if there is more than one author, the lead author shall define point for the other authors
d Maximum points for each of item 5 and 6: 30 and 7: 50

Appendix 14: The List of Minimum Number and Type of Specimens for the Level 1 and Level 2 Practical Examination

Product Sectors	**Method and Level**											
	UT 1	**UT 2**	**RT 1**	**RT 2**	**ET 1**	**ET 2**	**MT 1**	**MT 2**	**PT 1**	**PT 2**	**VT 1**	**VT 2**
Castings	2	2	2	2 + 12rs	2	2	2	2	2	2	2	2
Forgings	2	2	2	2 + 12rs	2	2	2	2	2	2	2	2
Welds	2	2	2	2 + 12rs	2	2	2	2	2	2	2	2
Tubes and pipes	2	2	2	2 + 12rs	2	2	2	2	2	2	2	2
Wrought products	2	2	2	2 + 12rs	2	2	2	2	2	2	2	2
Industrial Sectors (combining two or more product sectors)	**UT 1**	**UT 2**	**RT 1**	**RT 2**	**ET 1**	**ET 2**	**MT 1**	**MT 2**	**PT 1**	**PT 2**	**VT 1**	**VT 2**
Metal manufacturing	2	2	2	2 + 12rs	2	2	2	2	2	2	2	2
Pre-and in-service testing	3 c/f w	3 c/f w	2 c w	2 c w + 24rs	3 t w	3 t w	3 c/f w	3 c/f w	3 c/f w	3 c/f w	3 c/f w	3 c/f w

- Where the practical examination requires the testing of more than one specimen, the second or any subsequent specimens shall be different in character, e.g., in product form, material specification, shape, size, and discontinuity type, from those tested previously.
- Where, after the number of specimens required, product sectors are indicated by appropriate letters, this means that specimens from these sectors shall be included in the practical examination.
- For radiographic examination, Level 1 and Level 2 candidates shall radiograph at least two volumes – except for Level 2 candidates having passed a Level 1 qualification examination, where at least one volume is to be radiographed.
- Where a sector examination involves the testing of more than one product type, then the specimens tested shall be representative of all products or shall be selected at random by the Examiner from the product range or materials which make up the sector.
- A set of radiographs (12 or 24) shall be considered as one specimen.
- Key: c – casting; f – forging; w – weld; t – tube; c/f; casting or forging; rs – radiographs