IAEA TECDOC SERIES

IAEA-TECDOC-628/Rev. 3

Training Guidelines in Non-destructive Testing Techniques

2013 Edition

IAEA
International Atomic Energy Agency

TRAINING GUIDELINES IN NON-DESTRUCTIVE TESTING TECHNIQUES

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHAMAS
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BRUNEI DARUSSALAM
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DOMINICA
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FIJI
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LAO PEOPLE'S DEMOCRATIC REPUBLIC
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA, ISLAMIC REPUBLIC OF
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PAPUA NEW GUINEA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
RWANDA
SAN MARINO
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWAZILAND
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TOGO
TRINIDAD AND TOBAGO
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA, BOLIVARIAN REPUBLIC OF
VIET NAM
YEMEN
ZAMBIA
ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA-TECDOC-628/REV. 3

TRAINING GUIDELINES IN NON-DESTRUCTIVE TESTING TECHNIQUES

2013 EDITION

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2014

COPYRIGHT NOTICE

For further information on this publication, please contact:

Radioisotope Products and Radiation Technology Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
Email: Official.Mail@iaea.org

Printed by the IAEA in Austria
December 2014

IAEA Library Cataloguing in Publication Data

Training guidelines in non-destructive testing techniques :
2013 edition : IAEA-TECDOC-628/Rev. 3, 2014.
— Vienna : International Atomic Energy Agency, 2014.
p. ; 30 cm. — (IAEA-TECDOC series, ISSN 1011–4289 ; no. 628/Rev. 3)
ISBN 978–92–0–109214–4
Includes bibliographical references.

1. Non-destructive testing. 2. Materials — Testing.
3. Engineering inspection. I. International Atomic Energy Agency. II. Series.

IAEAL 14–00948

FOREWORD

The IAEA promotes industrial applications of radiation technology, including non-destructive testing (NDT), through activities such as Technical Cooperation Projects (national and regional) and Coordinated Research Projects. Through this cooperation, Member States have initiated national programmes for the training and certification of NDT personnel. National certifying bodies have also been established based on International Organization for Standardization (ISO) standards.

As part of these efforts, the IAEA has been actively involved in developing training materials. Consequently, IAEA-TECDOC-407, Training Guidelines in Non-destructive Testing Techniques, was published in 1987, then revised and expanded as IAEA-TECDOC-628 in 1991. Revisions of IAEA-TECDOC-628 were considered essential to meet the demands of end-user industries in Member States, and revised and expanded versions were issued in 2002 and 2008. These latter versions included work conducted by the International Committee for Non-Destructive Testing (ICNDT) and many national NDT societies. It is one of the publications referred to in ISO 9712:2005, Non-destructive Testing: Qualification and Certification of Personnel, which in turn is an internationally accepted standard, revised as ISO 9712:2012, Non-destructive Testing: Qualification and Certification of NDT Personnel.

This publication is an updated version of IAEA-TECDOC-628. The content of which has been revised following the changes of ISO 9712 converging with EN 473 and becoming EN ISO 9712:2012, based on the experience of experts and comments from end-user industries. The details of the topics on each subject have been expanded to include the latest developments in the respective methods.

The incorporated changes will assist the end-user industries to update their NDT qualification and certification schemes and course materials. This publication, like the previous versions, will continue to play an important role in international harmonization of NDT training and certification.

The IAEA wishes to express its appreciation to all those who contributed to this publication, to the governments and organizations whose support made this publication possible, and to all who revised and finalized the content. The modifications were made as a joint effort of three experts in the qualification and certification of NDT personnel and familiar with IAEA requirements for publishing technical documents: E. Azizova (Uzbekistan), I. Einav (Canada) and Nassir abd Ibrahim (Malaysia). The publication has been reviewed by R. Alami (Morocco), B. Artemiev (Russian Federation), C. Bellinco (Argentina), A. Bensittel (Morocco), J. Conte (Brazil) and R. Holstein (Germany).

The IAEA officer responsible for this publication was P. Brisset of the Division of Physical and Chemical Sciences.

EDITORIAL NOTE

This publication has been prepared from the original material as submitted by the contributors and has not been edited by the editorial staff of the IAEA. The views expressed remain the responsibility of the contributors and do not necessarily represent the views of the IAEA or its Member States.

Neither the IAEA nor its Member States assume any responsibility for consequences which may arise from the use of this publication. This publication does not address questions of responsibility, legal or otherwise, for acts or omissions on the part of any person.

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

The IAEA has no responsibility for the persistence or accuracy of URLs for external or third party Internet web sites referred to in this publication and does not guarantee that any content on such web sites is, or will remain, accurate or appropriate.

CONTENTS

1. INTRODUCTION

This publication contains a body of knowledge for Non-destructive Testing (NDT). It was developed to provide guidelines for applicants, trainers, training organizations, and certification bodies, detailing the subject matter and the content for each level of certification. It is general in nature but the contents of the training should be adapted to the needs, procedures, materials and products of the customer. The recommended training hours are consistent with the edition of the standard ISO 9712:2012 in effect at the time of preparation.

All formal training described in this publication contains a theoretical portion and a practical portion. Guidance is included on the range of equipment and materials needed for instruction in each method including proposals of distance training/E-learning.

There is a common core of material that is required by level 3 personnel in every method. This common material has been removed from the content for the particular method and included as a separate section.

All training should be followed by an examination and could lead to a certification. Examination and certification processes are not covered by this TECDOC, but detailed information about this can be found in ISO 9712:2012.

This TECDOC is applicable for the following 7 methods;

- Eddy current testing;
- Leak testing (hydraulic pressure tests excluded);
- Magnetic particle testing;
- Penetrant testing;
- Radiographic testing;
- Ultrasonic testing;
- Visual testing (direct unaided visual tests and visual tests carried out during the application of another NDT method are excluded).

NDT methods are now widely used in civil engineering as well for the evaluation of civil infrastructure. In general, the civil engineering applications are distinct and sufficiently different that training on the general knowledge of civil engineering should be addressed separately.

Radiation protection is an important topic of industrial radiography and is also well-covered in a different publication available from IAEA.

Training to this syllabus provides a general knowledge for the NDT operator. It does not represent an authorization to operate, since this remains the responsibility of the employer, and the employee may require additional specialized knowledge.

A table prior to every method description gives the recommended training hours for every area of knowledge. In the columns for level 2 and level 3 only the additional hours are stated. It is required that the candidate has completed the training in the lower level.

2. GUIDELINE FOR ORGANIZING TRAINING INCLUDING ADVANCED METHODS

2.1. GENERAL

For the introduction of new methods or for training of advanced methods not fitting into the conventional certification programmes, the organizational form of a seminar can be used. It is difficult to find usable course materials or training schedules because of the fast development of advanced methods. The time frame for such material would be typically less than a year. A number of key questions have to be answered in advance to make the seminar successful for the participants.

2.2. KEY QUESTIONS

2.2.1. Need of the customers

What are the expectations of the customer? What should the participants be able to do after the seminar? What skills are expected or what knowledge?

2.2.2. Number of potential participants

How many people will take part? This is important for class room size, practical working groups, number of trainers and assistants.

2.2.3. Existing applications

Which applications of the methods are used and in what industries? Is it possible to visit the site, to obtain pictures, and reports or to get a contribution?

2.2.4. Supplier of equipment

Who is offering equipment? Is he willing to give equipment for the seminar, practical exercises and demonstrations? Often suppliers have provided basic lessons about the method and the application. Is it possible to have more than one supplier?

2.2.5. Scientific background

What is the physical background of the method? Is there a university or institute working in this field? Are they willing to teach the basics? Are there books or standards available?

2.3. PREPARATION

The organization of the seminar depends on the answers to the key questions.

The first step is to form a small organizing committee. It should consist of a chairperson, a seminar organizer and some people from industries, suppliers and institutes. Their first task is to overview the sources, define the seminar targets and draft the time schedule. Trainers have

to be found for the lessons. Demonstrations and practical exercises need to be defined.

The next step is to establish the date (information sheet/ programme) for the seminar and to design an invitation for potential participants.

The trainers are asked to deliver a written presentation in advance. These presentations are revised and coordinated in the committee to avoid double lessons and to ensure that they are meeting the seminar expectations.

2.4. ORGANIZATION

The organizer has to start action once the organizing committee sees that there are enough sources and participants to perform the seminar.

- register the participants
- invite the trainers
- book rooms for lessons and demonstrations
- organize refreshments
- prepare a time schedule
- copy the course material for every participant
- prepare certificates of attendance
- organize financial affairs

2.5. PERFORMANCE

The organizer should be available during the full seminar. He is responsible for opening the seminar, introducing the trainers, coordinating the preparation of practical exercises and demonstrations.

He answers organisational questions of the participants. An important task is to ensure that the trainers are following the time schedule.

At the end of the seminar there should be a short written evaluation with the participants and the trainers. It should be asked if the seminar fulfilled the expectation of everybody, if the conditions were good and what proposals and wishes they have for a next seminar.

2.6. POST WORK

The organizer has to close all financial affairs. He will give away the certificates of attendance to the participants.

The organizing committee should meet again and review the evaluations for future seminars in order to improve the contents of the seminar.

If the organizing committee can see a need for more training, they have to decide to transform the seminar into a regular training programme.

I. GENERAL KNOWLEDGE Level 1

CONTENTS:

1.1 Non-destructive testing of materials
- 1.1.1 Definitions
- 1.1.2 Characteristics of NDT as a technology. Reasons for using NDT
- 1.1.3 Description and field of application of the most common 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 Limitations in the application of non-destructive testing
- 1.1.5 Responsibilities of personnel certified to level 1, 2 and 3 personnel

1.2 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, processing and in-service defects

SPECIFIC OBJECTIVES:

1.1 Given the instructor's explanations, the student will be able to:
- a) define non -destructive test;
- b) list the characteristics of NDT technology and the reasons for using NDT;
- c) compare the different types of NDT, with particular reference to the application and uses of each method.

1.2 Given the instructor's explanations, the student will be able to:
- a) explain the difference between defect and discontinuity;
- b) define the properties of materials, especially of metals;
- c) recognize how defects affect the properties of materials.

1.3 Processes and defects
- 1.3.1 Primary processes and related defects
  - a) Casting
  - b) Welding
  - c) Forging
  - d) Rolling
  - e) Heat treatment
  - f) Machining
  - g) Plating
- 1.3.2 In-service defects
  - a) Overload
  - b) Fatigue

c) Corrosion
d) Erosion
e) Brittle fracture
f) Others

1.4 Given the instructor's explanations, the student will be able to:

a) list various metallurgical processes of fabrication;
b) describe typical defects associated with each type of process;
c) describe typical defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion of examples and development from student experience.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Films, Course notes, Samples of materials with typical defects.

SUBJECT: GENERAL KNOWLEDGE **Level 2**

CONTENTS:

1.1 Basic 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

1.2 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
- 1.2.7 Materials in service and discontinuities formed during in-service

---

SPECIFIC OBJECTIVES:

1.1 Given the instructor's explanations, the student will be able to:
- a) define non-destructive testing;
- b) describe the basic principles and the method of application of the common NDT methods;
- c) discuss the best applications, limitations and problems relating to the use of each method.

1.2 Given the instructor's explanations, the student will be able to:
- a) describe the structure, physical and mechanical properties of metallic materials
- b) describe the various types of discontinuities and defects, their sources and their classification.

1.3 Given the instructor's explanations, the student will be able to:
- a) describe the method of steel fabrication and the related defects;
- b) describe the common manufacturing processes such as welding, casting, forging, and rolling and their related defects.
- c) describe the behaviour of materials in service, service conditions leading to defects and failures: corrosion; creep; fatigue; wear; overload; brittle fracture, erosion, others and the concepts of rupture development in metals

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

SPECIFIC OBJECTIVES:

---

2 6 Given the instructor's explanations, the student will be able to:
a) describe the basic concepts of quality and standardization;
b) list the basic elements of a quality system;
c) explain the basic premise of administration of information in a quality system.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, development from student experience and guided discussion of examples

---

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board, Course notes, Typical documents, i.e. codes, Samples of materials and defects and Films.

3. I. GENERAL KNOWLEDGE - BASIC COURSE FOR LEVEL 3

The following table details a number of subjects which are common to Level 3 training for all methods. They have been summarized separately, however course designers must provide for the subjects and the related hours.

№	Subject	Hours of training
1	NDT methods, materials and processes	16
2	Organization and administration of NDT	4
3	Quality assurance and standardization	6
4	Qualification and certification of NDT personnel	4
5	Revision of 4 main NDT methods	10
	TOTAL	40

Notes:

1. It is recommended that the Basic examination be passed first (before Level 3 methods examinations)

2. This Basic examination will remain valid provided that the first main method examination is passed within 5 years after passing the basic examination (§ 8.3.2.2 of ISO9712:2012)

BASICS - GENERAL KNOWLEDGE **LEVEL: 3**
SUBJECT: 1. NDT, MATERIALS AND PROCESSES

CONTENTS:

---

1 NDT Methods
1.1 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, fatigue crack, creep, hydrogen embrittlement, stress corrosion cracking, etc
1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

1.1 Given the instructor's explanations, the student will be able to:
a) define non-destructive testing;
b) describe the basic principles and the method of application of the common NDT methods;
c) discuss the best applications, limitations and problems relating to the use of each method.
1.2 Given the instructor's explanations, the student will be able to:
a) describe, interpret, analyze and evaluate the flaw's detection of metallic and non-metallic materials;
b) describe, interpret and analyze the main processes of fabricating materials;
c) describe, interpret and analyze the various types of surface finishing in metallic and non-metallic materials, including laps and adhesive bonding;
d) recognize various types of materials.
1.3 Metrology
1.3.1 Fundamental units of the International System (SI)
1.3.2 Usual derived units
1.3.3 Equivalence between units of various commonly used systems and those of the SI
1.4 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

BASIC - GENERAL KNOWLEDGE LEVEL: 3
SUBJECT: 2. QUALITY ASSURANCE AND STANDARDIZATION

CONTENTS:

2.1 Quality assurance
- 2.1.1 Basic principles for the application of quality assurance
- 2.1.2 Organization of quality assurance, Quality manual, Quality control, Auditing of quality.
- 2.1.3 Management and control of quality assurance documentation, quality control of testing
- 2.1.4 Certification and accreditation of NDT facilities
- 2.1.5 Reports on testing, documentation systems

2.2 Standardization
- 2.2.1 Definition of standardization, principles for writing of standards
- 2.2.2 Codes, standards, specification procedures and instructions
- 2.2.3 Procedure Writing, i.e format, structure, and content of procedures
- 2.2.4 Procedure validation

2.3 Reports and protocols

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:
- a) interpret and apply quality assurance procedures to the application of NDT at all stages;
- b) analyze, evaluate and prepare all testing documentation in accordance with the requirements of quality assurance;
- c) define requirements for quality assurance in the specific area of activity;.
- d) understand the difference between certification and accreditation;
- e) implement certification and accreditation processes.

2.2 Given the instructor's explanations, the student wi1 be able to:
- a) define standardization and discuss basic principles for writing of standards;
- b) discuss the benefit and applications of standards, codes, specifications and procedures;

2.3 Given the instructor's explanations, the student will be able to:
- a) explain the difference between codes, standards, specification, procedures, and instructions;
- b) select the information necessary to write a procedure related to codes and standards

2.4 Given the instructor's explanations, the student will be able to write the table of contents of a procedure and understand what kind of information should correspond to each topic

2.5 Given the instructor's explanations, the student will be able to
- c) write reports and keep records which meet the requirements of codes and standards;.
- d) implement procedure validations.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, development from student experience and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Video/slides, Films, Course notes, Quality assurance manuals and Typical documents.

BASIC - GENERAL KNOWLEDGE **LEVEL: 3**
SUBJECT: 3. ORGANIZATION AND ADMINISTRATION OF NDT

CONTENTS:

3.1 Organization and administration of NDT

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

3.1.3 Costs

a) Investments in equipment
b) Direct and indirect staff costs
c) Calculation and analysis of costs and profitability

3.1.4 Equipment selection and facility design

3.1.5 Operating procedures and record keeping

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:

a) organize and administer the performance of tests with an NDT method with proper consideration of the safety of personnel and facilities and economic factors;
b) organize the tasks of staff involved in NDT to ensure the operation is conducted safely and efficiently;
c) design a testing facility for the use of one or more NDT methods;
d) write operating procedures for the conduct of tests, equipment maintenance and record keeping and control of test items;
e) develop specifications for equipment procurement for specific testing applications.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion, development from student experience and example problems.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Course notes, Sample specifications and quotations and Sample procedures.

BASIC - GENERAL KNOWLEDGE LEVEL: 3
SUBJECT: 4. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL

CONTENTS:

4.1 Training, Qualification and Certification of NDT personnel
- 4.1.1 National standards for the qualification and certification of personnel.
- 4.1.2 Regional and international recommendations, e.g ISO 9712
- 4.1.3 Organization of courses and training in NDT methods
- 4.1.4 Code of ethics

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to:
- a) interpret and administer national and international standards for the qualification and certification of NDT personnel;
- b) organize, administer and evaluate training courses for NDT personnel;
- c) interpret and apply a code of ethics.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, development from student experience and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Applicable standards and documents, and Course notes.

4. II. INSPECTION METHOD: RADIOGRAPHIC TESTING

SUBJECT	HOURS OF TRAINING		
	LEVEL1	LEVEL 2	LEVEL3
1. GENERAL KNOWLEDGE	4	8	[1)]
2. PHYSICAL PRINCIPLES OF THE TEST	3	4	3
3. EQUIPMENT- RADIATION SOURCES	3	8	3
4. PHOTOGRAPHIC AND NON-PHOTOGRAPHIC RECORDING	4	8	4
5. WORK PARAMETERS AND CONDITIONS	4	8	3
6. DEFECTOLOGY	2	4	3
7. SELECTION OF TECHNIQUES	2	8	4
8. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	2	8	9
9. PERSONAL SAFETY AND RADIATION PROTECTION	16	12	5
10. SPECIAL APPLICATIONS	-	4	3
11. RECORDING AND INTERPRETATION OF RESULTS	-	8	3
TOTAL	40	80	40[1)]

[1] In addition to the above 40 hours a general knowledge basic course for level 3 (applicable to all NDT methods) is recommended, which shall be successfully completed only once..

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: See common Basic for GENERAL KNOWLEDGE

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS

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

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations and a type of radiation, the student will be able to:
- a) List its properties;
- b) Explain the characteristics of the spectrum;
- c) Calculate the variation in intensity of the radiation with distance;
- d) Recognize the basic units applied in radiographic testing.

2.2 Given the instructor's explanations, the student will be able to:
- a) Distinguish between radioactive decay, radioactivity and half -life;
- b) Explain the difference between artificial and natural radioactive sources.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including lecture, guided discussion and simple calculations.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Video/Slides and Table of nuclides.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.3 Interaction of radiation with matter
- 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

SPECIFIC OBJECTIVES:

2.3 Given the instructor's explanations, the student will be able to:
- a) compare the different processes of interaction of radiation with matter;
- b) relate the attenuation of radiation to half-thickness.

2.4 Given the instructor's explanations, the student will be able to:
- a) recognize the different systems of measuring ionization
- b) distinguish between the various radiations magnitudes;
- c) distinguish between types of radiation measuring instruments, describing their proper application.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including lecture, guided discussion and simple calculations.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Video/Slides, Film (if available), Course notes, Samples of various materials and Calculator.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 3. EQUIPMENT-RADIATION SOURCES

CONTENTS:

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

SPECIFIC OBJECTIVES:

3.1 Given the instructor’s explanations and a set of X ray equipment, the student will be able to:

a) identify the basic components and controls;
b) recognize the type of generator;
c) operate the equipment properly.

3.2 Given the instructor's explanations and a source of gamma radiation, the student will be able to:

a) recognize the type of radioisotope;
b) recognize the spectrum of the radioisotope and its activity;
c) operate the source correctly.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including lecture, guided discussion and individual practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Film (if available), Course notes, Samples of various materials, X-ray equipment, Radiological protection equipment (a radiation monitor and dosimeter as a minimum), and Gamma ray source.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 4. PHOTOGRAPHIC AND NON-PHOTOGRAPHIC RECORDING

CONTENTS:

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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student wi11 be able to:
a) recognize the structural components of a radiographic film;
b) relate the code of the film to its properties (grain size, contrast, speed);
c) distinguish between the types of screens and their applications.

4.2 Given the instructor's explanations, the student will be able to explain the nature of the fluoroscopic test and how it differs from film radiography.

METHODOLOGICAL STRATEGIES:

Instructor’s demonstration including lecture, guided discussion and practical laboratory work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,Film (if available), Course notes, Samples of various materials, Manual for various brands of film, and Screens.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

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

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to:

a) distinguish between the concepts of density, contrast, geometric penumbra and definition;
b) explain the effect of the various geometric factors with respect to definition of the radiographic image;
c) use the collimator, screens and filters to control scattered radiation;
d) distinguish between various types of image quality indicators in accordance with the standards and position them correctly in accordance with the test conditions;
e) carry out the practical radiographic work.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including lecture, guided discussion, workshop on exposure calculation problems, particular work on handling procedures, practical work on handling quality indicators and performance of radiography.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos， Film (if available), course notes, Samples of various materials, test procedures (written instructions for radiographic testing), Various types of quality indicators, Test pieces, screens, filters and masks, Meter, exposure curves, calculator, Densitometer, density samples, X-ray equipment, gamma ray equipment, and accessories.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

5.2 Care in the handling and conservation of film
- 5.2.1 Film handling
- 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)

SPECIFIC OBJECTIVES:

5.2 Given the instructor's explanations and an undeveloped radiographic film, the student will be able to:
   a) verify the condition of the reagents;
   b) handle the film correctly;
   c) carry out the processing correctly.

5.3 Given the instructor's explanations and various radiographs, the student shall demonstrate ability to interpret them, handling the viewer and film correctly.

5.4 Given the instructor's explanations and various radiographs, the student will be able to:
   a) recognize defective radiographs, identifying the various processing defects;
   b) determine radiographic density.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including lecture, guided discussion, practical work in processing and checking of reagents, practical work in handling the viewer and viewing of radiographs.

EQUIPMENT AND RESOURCES:

Radiographic film, Darkroom, Processing equipment, Drying equipment, Viewer, reference radiographs, Writing board, sample defective radiographs, Power Point/Transparencies and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 6. DEFECTOLOGY

CONTENTS:

6.1 Basic relationship between image and object
6.2 Radiographic indication of defects

SPECIFIC OBJECTIVES:

6.1 Basic relationship between image and object
6.2 Radiographic indication of defects
6.2.1 Radiography image of defects in weld
6.2.2 Radiography image of defects in cast products
6.2.3 Influence on detectability (type of defect; size; orientation, Imaged thickness range, Number of exposures).

METHODOLOGICAL STRATEGIES:

Instructor's demonstration includes delivery of support material, discussion and practical work in radiography, observation of radiographs.

EQUIPMENT AND RESOURCES:

Writing board, Standard radiographs, Viewer, Power Point/Transparencies, and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 7 SELECTIONS OF TECHNIQUES

CONTENTS:

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

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanations and work pieces of various materials, the student will be able to define the most suitable radiographic techniques, taking into account the type of material and the variables of exposure.

7.2 Given the instructor's explanations and work pieces of various shapes, the student will be able to describe the most suitable radiographic technique.

METHODOLOGICAL STRATEGIES

Instructor's demonstration including lecture, delivery of support material, guided discussion and practical work in selection of techniques.

EQUIPMENT AND RESOURCES:

Writing board, Work pieces of various materials, codes, Work pieces of different geometry, Radiographic equipment, Power Point/Transparencies, and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 8. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES.

CONTENTS:

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
- 8.3 Identification of radiographs and recording of tests

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations, the student will be able to:
- a) explain the significance and application of codes, standards, specifications and procedures;
- b) recognize the structure of codes and standards;
- c) recognize the different standards existing with respect to the application of radiographic testing;
- d) recognize the difference between standards, specifications and procedures.

8.2 Given the instructor's explanations and written instructions, the student will be able to carry out practical radiographic work, following the relevant instructions and noting the operational conditions of the test on data forms.

8.3 Given the instructor's explanations and various practical examples of performing radiographs in plants, the student will be able to describe a system of codified recording, correctly identifying the radiographs.

METHODOLOGICAL STRATEGIES

Instructor's demonstration including lecture, delivery of support material, guided discussion and practical application of written instructions, guidelines, discussion and workshop (filling out forms).

EQUIPMENT AND RESOURCES:

Writing board, Codes, standards (ASME, ASTM, DIN, API, BTS, COVENIN, JIS), Test procedures, Work pieces, and Radiographic equipment and accessories.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION

CONTENTS:

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

SPECIFIC OBJECTIVES:

9.1 Given the instructor's explanations, the student will be able to recognize the dangers of excessive exposure to X-rays or gamma rays.

9.2 Given the instructor's explanations and radiation protection standards, the student will be able to recognize the maximum permissible radiation doses and their effects on the organism.

9.3 Given the instructor's explanations, the student will be able to relate the exposure dose to variations in time, distance or shielding.

9.4 Given the instructor's explanations, the student will be able to understand the units used.

METHODOLOGICAL STRATEGIES

Instructor's demonstration including lecture, delivery of support material, guided discussion and problem workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Calculator, Dosimeters, monitors, Data recording forms, Radiographs in series, Examples of identification systems in radiographic testing.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1
SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION

CONTENTS:

9.4 Work place monitoring
- 9.4.1 Purpose of monitoring
- 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,
- 9.6.4 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 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

---

SPECIFIC OBJECTIVES:

9.1. Given the instructor's explanations, the student will be able to:

a) define the safety conditions under which X-ray and gamma ray equipment should be operated and the radiation detection equipment required;

b) handle warning systems.

9.2. Given the instructor's explanations & examples of emergency situations, the student will be able to explain the possible solutions to such emergencies.

METHODOLOGICAL STRATEGIES

Instructor's demonstration including lecture, guided discussion and practical emergency work.

EQUIPMENT AND RESOURCES:

Writing board, X-ray and gamma ray equipment, monitors, dosimeters, bunker warning system, col1imators, power point/transparencies and slides/videos

INSPECTION METHOD: RADIOGRAPHIC TESTING **LEVEL: 1**
SUBJECT: 10. ADVANCE RADIOGRAPHY TECHNIQUES

CONTENTS:

10.1 Introduction to Neutron Radiography Techniques
- 10.1.1 Basic Principle
- 10.1.2 Differences between neutron radiography and x- and gamma radiography
- 10.1.3 Application
- 10.1.4 Advantages and limitation

10.2 Introduction to Fluoroscopy Techniques
- 10.2.1 Basic Principle
- 10.2.2 Differences between fluoroscopy 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

---

SPECIFIC OBJECTIVES:

9.5 Given the instructor's explanations, the student will be able to differentiate between conventional x- and gamma radiography and neutron radiography, fluoroscopy and digital radiography techniques and equipment associated to them

9.6 Given the instructor's explanations and examples of emergency situations, the student will be able to identify various digital detectors used for digital radiography system

---

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and problem workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

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

---

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations and a type of radiation, the student will be able to:
- a) list its properties;
- b) determine the characteristics of the spectrum;
- c) determine the variation in intensity of radiation with distance;
- d) apply properly the units related to radiographic testing.

2.2 Given the instructor's explanations, the student will be able to:
- a) distinguish between radioactive decay, radioactivity and half-life;
- b) distinguish between natural and artificial radioactive sources;
- c) know the units of specific emission.

2.3 Given the instructor's explanations, the student will be able to distinguish between alpha and beta particles and neutrons.

2.4 Given the instructor's explanations, the student will be able to:
- a) analyze the various mechanisms of the interaction of radiation with matter;
- b) explain the absorption and attenuation of radiation;

2.5 Given the instructor's explanations, the student will be able to explain the measurement of ionization and the units used.

2.6 Given the instructor's explanations, the student will be able to describe the detection and measurement of X and gamma rays.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and problem workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 3. EQUIPMENT- RADIATION SOURCES

CONTENTS:

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations and a set of X-ray equipment, the student will be able to:
   a) identify its basic elements and controls;
   b) recognize the type of generators;
   c) operate the equipment correctly;
   d) recognize the various designs of conventional and other equipment.

3.2 Given the instructor's explanations and a source of gamma radiation, the student will be able to:
   a) recognize the type of isotope and camera;
   b) describe the physical parameters of radioisotopes;
   c) describe the applicable range of penetration in different materials for different sources;
   d) operate the source correctly.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and individual practical exercises.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies
Slides/Videos
X-ray equipment
Radiation protection equipment (radiation monitor and dosimeter as a minimum)
Gamma ray source in camera

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 4. PHOTOGRAPHIC AND NON-PHOTOGRAPHIC RECORDING

CONTENTS:

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)

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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to:

a) recognize the constituent parts of a radiographic film;
b) relate the film code to its properties (grain size, contrast, speed);
c) distinguish between the types of screens and their applications;
d) describe sensitometric and exposure curves for various materials.

4.2 Given the instructor's explanations, the student will be able to:

a) explain fluoroscopy, image intensification, TV systems etc, based on digital radiography;
b) explain the differences between fluoroscopy, conventional radiography and digital radiography.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, laboratory practical work and problem workshop.

EQUIPMENT AND RESOURCES:

Writing board,
Power Point/Transparencies,
Slides/Videos manuals for different makes of film,
Sensitometric curves,
Screens, fluoroscopy systems,
film scanner,
and digital radiography system.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

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),
5.1.11 Choices of correct IQI designation
5.1.12 Sensitivity calculation
5.1.13 QI 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

---

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to:

a) distinguish between the concepts of density, contrast, geometrical penumbra and definition, types of evaluation;
b) explain the action of various geometrical factors with respect to definition of the radiographic image;
c) use screens, collimators and filters for controlling scattered radiation;
d) distinguish between image quality indicators in accordance with the standards and explain their positioning in accordance with the test conditions;
e) choose the correct film type and prepare their exposure curves.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion, workshop on exposure calculation problems, practical exercise on handling procedures and practical exercises on handling quality indicators.

EQUIPMENT AND RESOURCES:

Writing board,
test procedures,
Power Point/Transparencies, Slides/Videos,
Various types of quality indicators, Sample work pieces,
Screens, filters and masks, Meter,
Exposure curves, Calculator, densitometer,
Density samples,
X-ray equipment, Accessories.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

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

SPECIFIC OBJECTIVES:

5.2 Given the instructor's explanations and an undeveloped radiographic film, the student will be able to:
- a) verify the conditions of the reagents and the darkroom;
- b) handle the film correctly;
- c) carry out the process correctly.

5.3 Given the instructor's explanations and various radiographs, the student will be able to evaluate them, using the viewer and film correctly.

5.4 Given the instructor's explanations and various radiographs, the student will be able to:
- a) distinguish between defective radiographs, recognizing the various processing defects;
- b) identify the image quality indicator;
- c) determine the density of the radiographs.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, practical exercises on procedure, control of reagents and viewing of radiographs.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos,
Radiographic film, Darkroom, Processing equipment, Drying equipment,
Viewer, Reference radiographs.
Writing board, Densitometers,
Film scanner and Image intensifier (CCTV systems).

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 6. DEFECTOLOGY

CONTENTS:

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
  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

---

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanations, the student will be able to make comparisons between image size and object, determining the values affecting this relationship.
6.2 Given radiographs of different work pieces, the student will be able to:
  a) recognize the indications of typical defects of welding and cast pieces, etc
  b) relate the type of discontinuity to its radiographic image.
6.3 Given the instructor's explanations and reference radiographs, the student will be able to evaluate various degrees of defect seriousness in accordance with references.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including delivery of support material, guided discussion, practical exercises on viewing of radiographs and practical exercises on interpretation and evaluation of radiographs.

EQUIPMENT AND RESOURCES:

Writing board, Standard refe rence radiographs, Sample radiographs, Viewer, Densitometers, Standards, Power Point/Transparencies, and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 7. SELECTION OF TECHNIQUES

CONTENTS:

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 anerrgy
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
  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

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanations and various work pieces of different materials, the student will be able to select the most suitable radiographic techniques, taking into account the density of the material and the variables of exposure.
7.2 Given the instructor's explanation and various work pieces of different shape, the student will be able to select the most suitable radiographic technique.
7.3 Given the instructor's explanations, the student will be able to analyze the range and limitations of defect detection by radiography.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and practical exercises on technique selection.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Work pieces of various materials (steel, aluminum, etc.), Codes, Work pieces of different geometry and Standards.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 8. CODES, STANDARDS, PROCEDURE AND SPECIFICATION

CONTENTS:

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)
- 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

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations and testing procedures, the student will be able to:
- a) demonstrate understanding of the significance and application of codes, standards, specifications and procedures;
- b) recognize the various standards existing for the application of radiographic testing;
- c) prepare instructions for testing.

8.2 Given the instructor's explanation, the student will be able to establish and evaluate tasks for level 1 personnel.
8.3 Given the instructor's explanations, the student will be able to formulate instructions for testing under special conditions.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion, practical exercises on interpretation of procedures and compilation of instructions.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Codes, Standards (ASME, ASTM, DIN, API, BSI, COVENIN, JIS), Test procedures and examples of instructions, Work pieces (steel, aluminum, etc.), Equipment and accessories, Radiographs.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION

CONTENTS:

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

SPECIFIC OBJECTIVES:

9.1 Given the instructor's explanations, the student will be able to recognize the dangers of excessive exposure to X-rays or gamma rays.

9.2 Given the instructor's explanations and standards of radiation protection, the student will be able to recognize the maximum permissible doses of radiation and their effects on the organism.

9.3 Given the instructor's explanations, the student will be able to explain the variation of exposure dose with variation in time, distance or shielding.

9.4 Given the instructor's explanations, the student will be able to:

a) recognize the safety conditions under which X-ray and gamma ray equipment as well as equipment for the detection of radiation should be operated;
b) handle warning systems;
c) calculate shielding and distances.

9.5 Given the instructor's explanations and examples of emergency procedures and situations, the student will be able to describe the possible solutions in such emergencies.

9.6 Given the instructor's explanations, the student will be able to the concept of radiography source security

9.7. Given the instructor's explanations the student will be able to explain the subject of source categorization and its relation with the security level

9.8 Given the instructor's explanations and examples the student will be able to explain some accidents that occur around the world and the lesson learned out of these events

---

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, calculator,
X-ray and gamma ray equipment,
Monitors, dosimeters, bunkers, and warning system.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 10. OTHER RADIOGRAPHY TECHNIQUES

CONTENTS:

10.1 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

SPECIFIC OBJECTIVES:

10.1 Given the instructor's explanations, the student will be able to describe radiography of non-metallic materials.

10.2 Given the instructor's explanations, the student will be able to describe various type of radiography (Neutron Radiography, Computed tomography (3 Dimensional Imaging), Stereography Radiography, Autoradiography, Electron emission radiography, In motion radiography, Flash radiography, Television radiography and xero radiography

---

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Course notes,
Writing board, Power Point/Transparencies, Slides/Videos,
Examples and DIR & CT systems.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2
SUBJECT: 11. RECORDING AND INTERPRETATION OF RESULTS

CONTENTS:

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

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

SPECIFIC OBJECTIVES:

11.1 Given the instructor's explanations and the various practical examples of making radiographs in the plant, the student will be able to:
   a) present a codified recording system, correctly identifying the radiographs;
   b) document the tests.

11.2 Given the instructor's explanations and various radiographs for a practical case, the student will be able to:
   a) present a model report;
   b) describe the cases of acceptance, repair or rejection.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, guided discussion, report and evaluation of radiographs.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, example radiographs, and applicable standards and colours.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON BASICS FOR LEVEL 3

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

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
- 2.4.1 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

---

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to describe the spectral characteristics and nature of ionizing radiation.

2.2 Given the instructor's explanations, the student will be able to explain the concepts and parameters relating to the radioactive sources used in the testing.

2.3 Given the instructor's explanations, the student will be able to:
- a) describe various mechanisms for the interaction of radiation with matter and its application in radiographic testing;
- b) explain the absorption and attenuation of radiation in materials.

2.4 Given the instructor's explanations, the student will be able to solve problems relating to radiation detection and dosimetry.

2.5 Given the instructor's explanations, the student will be able to explain the principles applied in various detection systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and problem solving.

EQUIPMENT AND RESOURCES:

Writing board, transparencies, slides, chart of radionuclides and radioactive decay.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 3. EQUIPMENT- RADIATION SOURCES

CONTENTS:

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

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:
   a) explain the principles of designing equipment and accessories.

3.2 Given the instructor's explanations, the student will be able to:
   a) design facilities for industrial radiography.

3.2 Given the instructor's explanations, the student will be able to:
   a) design collimators;
   b) design and evaluate radiographic viewers and lighting systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, X-ray equipment, Radiation protection equipment (one radiation monitor and one dosimeter as a minimum).

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 4. PHOTOGRAPHIC AND NON-PHOTOGRAPHIC RECORDING

CONTENTS:

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
- 4.2.1 Differences and similarity between film and digital radiography
- 4.2.2 Concept of digital radiography (formation of digital image)
- 4.2.3 Film digitization
- 4.2.4 No Film digital radiography-computed radiography (phosphorus imaging plate)
- 4.2.5 Flat panel (amorphous silicon detector and digital detector array)
- 4.2.6 Filmless fluoroscopy-(application of coupled charged device detector)
- 4.2.7 Digital image processing (application of various software e.g ISee. Artist, etc)
- 4.2.8 Standards related to the application of digital radiography
- 4.2.9 Application of digital radiography
- 4.2.10 Advantages and limitations of digital radiography
- 4.2.11 Introduction to computed tomography (3 dimensional imaging)

4.3 Xero radiography

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to:
- a) evaluate structural characteristics of radiographic fi1m;
- b) describe the behaviour and application of various types of radiographic film, including paper and special types;
- c) compare and evaluate the various types of screens and their applications.

4.2 Given the instructor's explanations, the student will be able to conduct operation with real time radiographic systems.

4.3 Given the instructor's explanations, the student will be able to carry out tests using xeroradiography, real time radiography , and digital radiography and get acquainted with CT systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, laboratory practical work and problem workshop.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board, Manuals for different makes of films, Sensitometric curves, Screens.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

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

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to select, design and evaluate testing procedures as a function of operating specifications and techniques.
5.2 Given the instructor's explanations, the student will be able to apply and evaluate real time fluoroscopy.
5.3 Given the instructor's explanations, the student will be able to design and evaluate film processing facilities.
5.4 Given the instructor's explanations, the student will be able to design and evaluate the conditions for film viewing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and review of radiographs.

EQUIPMENT AND RESOURCES:

Radiographic film, Darkroom, Processing equipment, Viewers, Demonstration radiographs, Standard reference radiographs, Power Point/Transparencies,and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 6. DEFECTOLOGY

CONTENTS:

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.).
  6.2.2 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)

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanations, the student wi11 be able to analyze and evaluate radiographic findings and relate them to defectology.
6.2 Given the instructor's explanations and reference radiographs, the student will be able to analyze and evaluate the reliability of the radiographic information.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and supervised student practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Standard reference radiographs, Viewers, and Densitometers.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 7. SELECTION OF TECHNIQUES

CONTENTS:

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

---

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanations, the student will be able to design and evaluate techniques for various types of materials.
7.2 Given the instructor's explanations, the student will be able to select radiographic techniques as a function of specimen geometry and accessibility.
7.3 Given the instructor's explanations, the student will be able to analyze and discuss the validity of the results.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and supervised practical work in selection of techniques.

EQUIPMENT AND RESOURCES:

Writing board, Work pieces of various materials and geometries (steel, aluminum, etc.), Power Point/Transparencies, and Slides/Videos.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 8. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

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 Radiography procedure
  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.

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations and a review of applicable codes and standards, the student will be able to develop procedures and evaluate results in compliance with these standards.
8.2 Given national and international standards and specific inspection requirements, the student will be able to develop and evaluate specifications for radiographic testing.
8.3 Procedure writing exercises.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, review of standards, specifications and procedures and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, National and international codes and standards, and Typical specifications.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION

CONTENTS:

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 facilities 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

9.5 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

SPECIFIC OBJECTIVES:

9.1 Given the instructor's explanations and international regulations, the student will be able to develop radiation protection procedures and manuals for the use and maintenance of equipment and facilities.

9.2 Given the instructor's explanations, the student will be able to design and calculate shielding and packaging for the safe transport of radioactive sources.

9.3 Given the instructor's explanations, the student will be able to devise and evaluate radiation protection conditions in facilities for industrial radiography.

9.4 Given the instructor's explanations, the student will be able to plan, conduct and evaluate field operating procedures to ensure adequate protection of personnel.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, calculation exercises and problem solving.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board,
Typical documents,
Course notes,
International regulations and recommendations,
Installation plans,
Comparative tables,
Monitors, Dosimeters.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 10. SPECIAL APPLICATIONS

CONTENTS:

10.1 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
  10.11.2 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

SPECIFIC OBJECTIVES:

10.1 Given the instructor's explanations, the student will be able to describe radiography of non-metallic materials.
10.2 Given the instructor's explanations, the student will be able to describe various type of radiography (Neutron Radiography, Computed tomography (3 Dimensional Imaging), Stereography Radiography, Autoradiography, Electron emission radiography, In motion radiography, Flash radiography, Television radiography and xero radiography
10.3 Given the instructor's explanations, the student will be able to develop and evaluate procedures for testing non -metallic materials.
10.4 Given the instructor's explanations, the student will be able to develop and evaluate procedures to apply radiographic testing in particular industries and environments.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations, problem- solving and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Test pieces, and Demonstration radiographs.

INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 3
SUBJECT: 11. RECORDING AND INTERPRETATION OF RESULTS

CONTENTS:

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

SPECIFIC OBJECTIVES:

11.1 Given the instructor's explanations, the student will be able to compare and evaluate various means of recording the radiographic test.
11.2 Given the instructor's explanations, the student will be able to evaluate and select appropriate means of handling the radiographic images once recorded.
11.3 Given the instructor's explanations and his own experience, the student will be able to evaluate the validity of the interpretation of test results, with respect to specifications, the nature of the specimen and the parameters of the test.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and supervised problem- solving and practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Various types of imaging equipment, and Sample test reports and radiographs.

5. III. INSPECTION METHOD: ULTRASONIC TESTING

SUBJECT	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	8	[1)]
2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS	8	8	5
3. TESTING TECHNIQUES AND THEIR LIMITATIONS	4	8	5
4. EQUIPMENT AND ACCESSORIES	4	6	6
5. CALIBRATION OF THE TESTING SYSTEM	8	12	3
6. SPECIFIC APPLICATIONS	4	12	4
7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	4	10	9
8. RECORDING AND EVALUATION OF RESULTS	4	10	2
9. SPECIAL TECHNIQUES	-	6	6
TOTAL	40	80	40[1)]

[1)] [1] In addition to the above 40 hours of general knowledge Basic course for level 3 (applicable to all NDT methods) is required, which shall be successfully completed only once..

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 1
SUBJECT: 2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS

CONTENTS:

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

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

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to list the properties of ultrasonic waves.

2.2 Given the instructor's explanations, the student will be able to:
- a) define frequency, amplitude, length, speed of propagation;
- b) state the mathematical expression relating speed of propagation, wavelength and frequency.

2.3 Given the instructor's explanations, the student will be able to define acoustic impedance, stating the corresponding mathematical expressions.

2.4 Given the instructor's explanations, the student will be able to:
- a) define longitudinal and transverse waves, specifying their characteristics;
- b) state the relationship between wave type and application of test.

2.5 Given the instructor's explanations, the student will be able to:
- a) define reflection and refraction;
- b) represent graphically the possible mode conversions when the beam is incident at non-zero angle with respect to normal;
- c) state the causes of attenuation.

2.6 Given the instructor's explanations, the student will be able to:

a) state the principle of conservation of energy;

b) list the energies involved in ultrasonic testing, describing the way in which the energies change.

2.7 Given the concept of piezoelectricity, the student will be able to:

a) define its nature;

b) list the materials which exhibit this property and which are currently used in ultrasonic.

2.8 Given the instructor's explanations, the student will be able to:

a) define sonic field;

b) explain the relationship between transducer size, frequency and tested material on sonic field.

2.9 Given the instructor's explanations and a transducer, the student will be able to:

a) recognize its type and structural characteristics;

b) compare it with the other types of transducers, stating the basic differences between them;

c) describe its use or application.

2.10 Given the instructor's explanations and the concepts of near field and far field the student will be able to:

a) state the characteristics of each and the main differences between them;

b) state the mathematical relationship which limits them;

c) represent graphically the sonic field for a transducer, indicating the near and the far field;

d) correctly interpret the beam shape for different transducers.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, lecture, practical exercises and problem workshop

---

EQUIPMENT AND RESOURCES:

Writing board, Various types of transducer, Calculators, Power Point/Transparencies, Slides/Videos, and Visual animations.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 1
SUBJECT: 3. TESTING TECHNIQUES AND THEIR LIMITATIONS

CONTENTS:

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

---

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:
  a) state the basic principle of the pulse- echo technique;
  b) list the applications and limitations of the technique.
3.2 Given the instructor's explanations, the student wi11 be able to:
  a) describe the nature of the transmission technique;
  b) list the applications and limitations of the transmission technique.
3.3 Given the instructor's explanations, the student will be able to describe the resonance technique.
3.4 Given the instructor's explanations, the student will be able to:
  a) define coupling;
  b) define the characteristics of a good couplant;
  c) list five different substances which can be used as couplants;
  d) relate the different techniques to the method of coupling;
  f) setting range and sensitivity.
3.5 Given the instructor's explanations, the student will be able to list the characteristics of an automatic testing system;

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos.

INSPECTION METHOD: ULTRASONIC TESTING **LEVEL: 1**
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

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
- 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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations and a set of ultrasonic (A-scan) equipment, the student will be able to recognize the controls and describe the specific function of each.
4.2 Given the instructor's explanations and ultrasonic equipment for thickness measurements, the student will be able to:
a) recognize the type of equipment;
b) recognize each of the controls and its function;
c) operate the equipment correctly.
4.3 Given the instructor's explanations and a set of ultrasonic equipment, the student will be able to explain the use of the monitor.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, delivery of support materials and practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, ultrasonic equipment with analogue and digital displays, Transducers

INSPECTION METHOD: ULTRASONIC TESTING **LEVEL: 1**
SUBJECT: 5. CALIBRATION OF THE TESTING SYSTEM

CONTENTS:

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 block and test piece, comparison with reference blocks
5.4 Variable effects, transmission accuracy
5.5 Calibration requirements and reflectors
5.6 Inspection calibration

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to:
  a) perform the calibration correctly at a distance with normal sensors (single and. double crystals);
  b) explain the difference in the calibration of the two graphs obtained for the two types of sensors;
  c) state the applications, advantages and limitations for each of the calibration systems with different sensors.
5.2 Given the instructor's explanations and the procedures, the student will be able to:
  a) perform the calibration correctly with an angular sensor;
  b) distinguish between calibration techniques for angular sensors;
  c) locate the beam exit point and verify the angle.
5.3 Given the instructor' s explanations and a calibration, the student will be able to adjust the calibration to compensate for the difference in speed of ultrasonic propagation between the calibration block and the test piece.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, lecture and practical demonstration.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, film (if available), course notes, samples of various materials, written instructions for ultrasonic testing, ultrasonic equipment, normal sensors (single and double crystals), test pieces of simple geometry, calibration units, couplant, normal sensors (different angles), and sample work pieces.

INSPECTION METHOD: ULTRASONIC TESTING **LEVEL: 1**
SUBJECT: 6. SPECIFIC APPLICATIONS

CONTENTS:

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
- 6.2.2 Influence of surface condition

6.3 Influence of geometry and structure
6.4 Detection of corrosion

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanations, the student will be able to list the possible flaws which occur in work pieces of simple geometry.
6.2 Given the instructor's explanations, the student wi11 be able to relate the speed of sound propagation to the type of material.
6.3 Given the instructor's explanations, the student will be able to describe the difficulties in detecting corrosion.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, delivery of support materials, problem workshop and practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Film (if available), Course notes, Samples of various materials, Calculator, Ultrasonic equipment, Accessories, and Test pieces.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 1
SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

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

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanations, the student will be able to recognize the different codes and standards which exist for the application of ultrasonic testing.
7.2 Given the instructor's explanations and the written procedural instructions, the student will be able to carry out a test, correctly interpreting the instructions and terms used.
7.3 Given the instructor's explanations and requisite forms, the student will be able to record the results of the test in proper format.
7.4 Given the instructor's explanations and requisite forms, the student will be able to prepare the test report completing all of its requirements.

METHODOLOGICAL STRATEGIES

Instructor's presentation including lecture, guided discussion and practical exercises.

EQUIPMENT AND RESOURCES:

Writing board, Codes and standards ASME, ASTM, DIN, API, COVENIN, JIS, BSI, IRAM, Ultrasonic equipment and accessories, Test pieces of simple geometry, Power point/Transparencies, Slides/Videos.

INSPECTION METHOD: ULTRASONIC TESTING **LEVEL: 1**
SUBJECT: 8. RECORDING AND EVALUATION OF RESULTS

CONTENTS:

8.1 Recording of the test results
- 8.1.1 Position of defects
- 8.1.2 Echo amplitude
- 8.1.3 Acceptance levels

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations and the test procedure for a work piece, the student will be able to note correctly on the recording form the results of the test with respect to the position and size of the reflector, as detected by the average value technique.

METHODOLOGICAL STRATEGIES

Instructor's presentation including guided discussion and practical work.

EQUIPMENT AND RESOURCES:

Procedures, Recording sheets, Ultrasonic equipment and accessories, Power Point/Transparencies, Slides/Videos.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS

CONTENTS:

2.1 The nature of ultrasonic waves
2.2 Characteristics of wave propagation
  2.2.1 Frequency
  2.2.2 Amplitude
  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
  2.7.3 Field divergence
2.8 Attenuation of sound: Cause and effect; principles of measurement of attenuation

---

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to describe the nature of ultrasonic waves.
2.2 Given the instructor's explanations, the student will be able to:
  a) define frequency, amplitude, length, velocity, impedance, acoustic pressure and intensity;
  b) determine the corresponding mathematical relationships.
2.3 Given the instructor's explanations, the student will be able to:
  a) define longitudinal waves, surface waves and lamb waves and describe their characteristics;
  b) explain the relationship between the type of wave and its application.
2.4 Given the instructor's explanations, the student will be able to:
  a) distinguish between normal and angular incidence;
  b) define reflection and refraction;
  c) explain mode conversion.

2.5 Given the instructor's explanations, the student will be able to:

a) describe the characteristics of energy transfer from one medium to another;
b) explain the generation of ultrasonic waves and the cause of energy loss in various media.

2.6 Given the instructor's explanations, the student will be able to:

a) explain the piezoelectric and magnetostrictive effects;
b) compare the advantages and disadvantages of various crystal materials.

2.7 Given the instructor's explanations of the concepts of near and far field. The student will be able to:

a) identify the characteristics of near and far fields and differentiate between them;
b) state the limiting mathematical relationship;
c) illustrate graphically the sonic field for a transducer, indicating the near and far fields;
d) interpret correctly the sonogram for different sensors.

2.8 Given the instructor's explanations, the student will be able to define ultrasonic attenuation

---

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Course notes, Writing board, Power Point/Transparencies, Slides/Videos, Ultrasonic instrument, Various transducers, Calibration blocks.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 3. TESTING TECHNIQUES AND THEIR LIMITATIONS

CONTENTS:

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
  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 1,2,3a,3b,4 (BS 3923); planar defects; volumetric defects; discrete reflectors; diffuse reflectors.

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:
  a) explain the principle of each of the methods;
  b) list the applications and limitations of the methods.
3.2 Given the instructor's explanations, the student wil1 be able to:
  a) distinguish between the various types of sensors;
  b) perform the calculation for obtaining the angle of incidence.
3.3 Given the instructor's explanations, the student wi11 be able to:
  a) explain each of the techniques;
  b) list the applications and limitations of each technique.
3.4 Given the instructor's explanations, the student will be able to list the limitations which restrict the use of the ultrasonic test method.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Ultrasonic Unit, Various transducers, Calibration blocks, and Specimen sensors.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

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 systems4.2 Characteristics of equipment and system controls

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
- 4.2.3 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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, practical exercises and demonstrations, the student will be able to explain the functions of the ultrasonic instrument and recognize a malfunction of a component.

4.2 Given several types of ultrasonic instrumentation and the instructor's demonstration and explanation, the student will be able to explain the different functions of each, calibrate each type and identify malfunctions.

4.3 Given several types of instrumentation and the instructor's explanations, the student wi11 be able to explain the significant characteristics of each and to select the appropriate instrument for each inspection problem.

4.4 Given the instructor's explanations and demonstration, the student will be able to operate various types of recording instrumentation in conjunction with an ultrasonic instrument.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion, demonstrations and practical exercises.

EQUIPMENT AND RESOURCES:

Ultrasonic equipment, transducers, recording equipment, Power Point/Transparencies, Slides/Videos, writing board.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 5 CALIBRATION OF THE TESTING SYSTEM

CONTENTS:

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)
5.5 DGS method
5.6 Sizing techniques, principles and limitations
5.7 Coupling medium

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the necessary equipment and calibration blocks, the student will be able to test the horizontal and vertical linearity of the equipment.
5.2 Given the instructor's explanations and the necessary equipment, the student will be able to:
  a) test the sensor to determine its sensitivity and resolution;
  b) determine the exit point and angle of incidence for an angle sensor.
5.3 Given an explanation of the procedures and the necessary equipment, the student will be able to perform calibration using curved work pieces.
5.4 Given the instructor's explanation of the procedures, the student will be able to construct a DAC curve.
5.5 Given the instructor's explanations, the student will be able to make evaluations with DGS curves.
5.6 Given the instructor's explanations, the student will be able to explain the advantages of various types of coupling media.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and practical exercises.

EQUIPMENT AND RESOURCES:

Writing board, sample written procedures, calibration blocks, coupling materials, UT equipment, Sample DGS curves, Power Point/Transparencies, and Slides/Videos.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 6. SPECIFIC APPLICATIONS

CONTENTS:

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
- 6.1.6 Non-metallic materials (ceramics, plastics, etc.)
- 6.1.7 Bonded structures

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanation and demonstrations, the student will be able to:

a) explain how the test should be performed, the type of transducers to be used, the frequency, probe angle and scanning direction and sizing techniques;

b) describe the manufacturing processes, geometries and possible types of discontinuities in each case.

c)

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Demonstration work pieces, Ultrasonic equipment accessories and test samples.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

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.
  - f)

SPECIFIC OBJECTIVES:

7.1 Given a collection of standards and specifications relating to ultrasonic testing and the instructor's explanation, the student will be able to distinguish between and relate findings to them.
7.2 Given the instructor's presentation of a specific case, the student will be able to:
  a) define the test procedure;
  b) prepare a report based on the procedure.
  c)

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion

---

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Writing board, Typical codes, standards, specifications and procedures, Ultrasonic equipment, accessories and test samples.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 8. RECORDING AND EVALUATION OF RESULTS

CONTENTS:

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

---

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations, the student will be able to identify the various types of defects.
8.2 Given the instructor's demonstration and the sample work piece, the student will be able to recognize and evaluate discontinuities in accordance with a specific code.
8.3 Given the instructor's explanations and the results of an evaluation of a sample work piece, the student will be able to record and report on the test.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and practical exercises.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Ultrasonic equipment and accessories, Test pieces, Procedures, Report forms, and Course notes.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2
SUBJECT: 9. SPECIAL TECHNIQUES

CONTENTS:

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.

SPECIFIC OBJECTIVES:

9.1 Given the instructor's demonstrations and explanations, the student will be able to identify special inspection problems and select appropriate approaches.
9.2 Given the instructor's demonstrations and explanations, the student will be able to understand the use of automated and semi- automated testing techniques.
9.3 Given the instructor's demonstrations and explanations, the student will be able to understand the special techniques used for data processing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including demonstration.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, slides/Videos, Film, Samples, and UT equipment for each of Special Technique and accessories.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE FOR LEVEL 3

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS

CONTENTS:

2.1 Nature of ultrasonic waves
2.2 Characteristics of ultrasonic wave propagation: frequency, wavelength, velocity, acoustic impedance, acoustic energy, acoustic intensity, amplitude.
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.

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student wi11 be able to discuss the nature of ultrasonic waves.
2.2 Given the instructor's explanations, the student will be able to:
  a) define frequency, amplitude, length, velocity, impedance, acoustic pressure and intensity;
  b) apply the corresponding mathematical relationships;
2.3 Given the instructor's explanations, the student will be able to:
  a) define longitudinal waves, surface waves and Lamb waves and describe their characteristics;
  b) determine the relationship between the type of the wave and its applications;
2.4 Given the instructor's explanations, the student will be able to:
  a) distinguish between normal and angular incidence;
  b) explain reflection and refraction; mode conversion.
2.5 Transfer of energy from one medium to another, generation of ultrasonic waves , energy losses in various media.
2.6 Piezoelectric effect and magnetostrictive effect in crystals
2.7 Isotropic and anisotropic materials, phenomena of guided propagation
2.8 Far field and near field, influence of the speed of sound and the size of the transducer, divergence of the field, Fresnel and Fraunhofer zones.

2.9 Attenuation of sound, cause, effect, principles of measurement
2.10 Relation between sound velocity and elastic properties in metal

---

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, UT equipment, transducers, accessories.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 3. TESTING TECHNIQUES AND THEIR LIMITATIONS

CONTENTS:

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
- 3.3.6 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

SPECIFIC OBJECTIVES:

---

3. Given the instructor's explanations, the student will be able to:
   a) explain the principle of each of the techniques, its application and limitations;
   b) distinguish between the different types of sensors and perform the calculation to obtain the angles;
   c) describe the various operational techniques and determine their applications and 1imitations;
   d) determine the limits of ultrasonic testing for each type of application.

METHODOLOGICAL STRATEGIES:

Instructor' s demonstration including guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Sample transducers, film,
UT equipment and relevant transducers (probes).

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

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
  4.2.3 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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, practical exercises and demonstrations, the student will be able to explain the functions of the ultrasonic instrument and recognize a malfunction of a component.
4.2 Given several types of ultrasonic instrumentation and the instructor's demonstration and explanation, the student will be able to explain the different functions of each. calibrate each type and identify malfunctions.
4.3 Given several types of instrumentation and the instructor's explanations, the student will be able to explain the significant characteristics of each and to select the appropriate instrument for each inspection problem.
4.4 Given the instructor's explanations and demonstration, the student will be able to operate various types of recording instrumentation in conjunction with an ultrasonic instrument.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion, demonstrations and practical exercises.

EQUIPMENT AND RESOURCES:

Ultrasonic equipment, recording equipment, Power Point/Transparencies, Slides/Videos, writing board.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 5. CALIBRATION OF THE TESTING SYSTEM

CONTENTS:

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
  - 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.

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to establish procedures for the calibration of equipment.

5.2 Given the instructor's explanations, the student will be able to establish procedures for the calibration and sensitivity of the test.

5.3 Given the instructor's explanations, the student will be able to establish suitable procedures for optimizing the transmission of energy across the surface being explored.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion, demonstrations and practical exercises.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Test equipment, transducers, accessories and calibration blocks.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 6. SPECIFIC APPLICATIONS

CONTENTS:

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
- 6.1.8 Non-metallic materials (ceramics, plastics, etc.)
- 6.1.9 Bonded structures

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanation and demonstrations, the student will be able to:

a) explain how the test should be performed, the type of sensor to be used, the frequency, probe angle and scanning direction

b) describe the manufacturing processes, geometries and possible types of discontinuities in each case.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Equipment and accessories, Samples containing discontinuities.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

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

---

SPECIFIC OBJECTIVES:

7.1. Given the instructor's explanations and the results of practical exercises, the student wi11 be able to interpret, analyze and explain examination specifications developed by design engineers or specified in codes.

7.2. Given the instructor's explanation, the student will be able to analyze, interpret and discuss the validity of testing procedures in relation to the applicable specifications, codes and standards.

7.3. Given the instructor's explanation and the results of practical work, the student will be able to analyze, evaluate and draft complete testing procedures for whatever type of specimen is to be examined and for whatever ultrasonic technique is required, with interpretation of results.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, discussion of examples, guided discussion and practical exercises.

EQUIPMENT AND RESOURCES:

Writing board, transparencies, slides, examples of design specifications,
Applicable codes and standards, examples of general and specific procedures.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 8. RECORDING AND EVALUATION OF RESULTS

CONTENTS:

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

SPECIFIC OBJECTIVES:

8.1 Given an ultrasonic instrument, a test piece containing one or more discontinuities and the instructor's explanations, the student will be able to recognize various types of defects by the instrument's response.
8.2 Given the instructor's explanations, the student will be able to recognize and evaluate discontinuities in accordance with a specific code.
8.3 Development of clear procedures and instructions including acceptance criteria based on codes, standards and design specifications
a.4 Given the instructor's explanations, the student will be able to:
a) interpret and discuss the test results;
b) establish the conditions for preparing the report.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Equipment, Test pieces
Codes, and Procedures.

INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3
SUBJECT: 9. SPECIAL TECHNIQUES

CONTENTS:

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

SPECIFIC OBJECTIVES:

9.1 Given the instructor's explanations, the student will be able to:
a) state the principles of applying each special technique;
b) evaluate the possible application of each special technique to industrial problems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and practical exercises.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Equipment and test samples.

6. IV. INSPECTION METHOD: MAGNETIC PARTICLE TESTING

SUBJECT	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	5	[1)]
2. PHYSICAL PRINCIPLES AND FUNDAMENTALS OF MAGNETIC PARTICLES	3	3	2
3. METHODS AND TECHNIQUES	4	4	3
4. EQUIPMENT AND ACCESSORIES	2	3	3
5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	1	3	8
6. PRESENTATION AND RECORDING OF RESULTS	2	2	2
7. INTERPRETATION OF RESULTS LIMITATIONS	-	4	2
TOTAL	16	24	20[1)]

[1)] In addition to the above 20 hours a general knowledge common core course for level 3 (applicable to all NDT methods) is recommended, which shall be successfully completed only once.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 2. PHYSICAL PRINCIPLES AND FUNDAMENTALS OF MAGNETIC PARTICLES

CONTENTS:

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

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:
- a) define the key terms such as current, voltage and resistance and to relate them to each other;
- b) explain the fundamental differences between alternating and direct current.

2.2 Given the demonstrations and explanations in class, the student wi11 be able to:
- a) define terms used in magnetic testing such as magnet, magnetic poles, magnetic fields, lines of force and magnetic flux;
- b) distinguish between:
  - i) permanent and temporary magnets
  - ii) ferro-, para-, and dia-magnetic materials
- c) in the hysteresis curve, recognize and define:
  - i) the magnetization force,
  - ii) magnetic flux,
  - iii) reluctance
- d) illustrate the magnetic field around a conductor, solenoid and electromagnet.

2.3 Given an explanation of the concepts involved, the student shall be able to explain the difference between ultraviolet and visible light.

2.4 Given the instructor's explanations, the student will be able to recognize the terms and observations most commonly used in magnetic testing.

METHODOLOGICAL STRATEGIES:

Instructor's explanations using lecture method, guided discussion and demonstrations of magnetic field using magnets and iron particles.

EQUIPMENT AND RESOURCES:

Magnets, magnetizable particles, Power Point/Transparencies, Slides/Videosand writing board, samples of types of lights, lightmeters, and demonstration equipment.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

3.1 Methods of magnetization:
- 3.1.1 Longitudinal
- 3.1.2 Circular
- 3.1.3 Vertical

3.2 Magnetization techniques:
- 3.2.1 Permanent magnets
- 3.2.2 Electromagnets
- 3.2.3 Coils
- 3.2.4 Passage of current
- 3.2.5 Central conductor

SPECIFIC OBJECTIVES:

3.1 Given various magnetized work pieces, the student will be able to:
- a) find the direction of the magnetic field and current in each of them;
- b) explain the relationship between field direction and the orientation of discontinuities which may be detected;
- c) list the characteristics of the longitudinal and circular magnetic fields and distinguish between them.

3.2 Given a demonstration and explanation of magnetization techniques, the student will be able to:
- a) define the applications and limitations of each technique;
- b) determine the type of magnetization produced in each technique;
- c) measure the direction of the magnetic field produced in each technique.

METHODOLOGICAL STRATEGIES:

Instructor's explanations using lecture method, demonstrations, guided discussion and a problem workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Basic equipment for magnetization, Magnetic ink and Magnetizable test pieces.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

3.3 Inspection techniques
- 3.3.1 Remnant fields
- 3.3.2 Continuous field
- 3.3.3 Wet method
- 3.3.4 Dry method
- 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 remanant fields

---

SPECIFIC OBJECTIVES:

3.3 Given a background in the theory of magnetic particles and the means of application, the student will be able to:
- a) distinguish between continuous and remnant magnetization and recognize the characteristics of the materials to be tested by each technique;
- b) explain the difference between wet and dry methods and identify the characteristics of the particles to be used in each case;
- c) verify the presence of a magnetic field.

3.4 Given the explanations and demonstrations, the student will be able to:
- a) describe the principles on which magnetization is based;
- b) list the methods for demagnetization;
- c) verify the remnant field.
- d) explain the reasons for demagnetization
- e)

METHODOLOGICAL STRATEGIES:

Instructor's explanations using lecture method, demonstrations, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Samples, writing board, power Point/transparencies, slides/videos, equipment for magnetization, magnetic ink, magnetizable test pieces, and Gaussmeter and/or indicator.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

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

SPECIFIC OBJECTIVES:

4.1 Given a demonstration and explanation of the use of the equipment, the student will be able to:
- a) recognize the main types of magnetization equipment;
- b) identify the test capacity of each type of equipment;
- c) identify the type of current used in each type of equipment;
- d) identify the type of field generated by each type of equipment;
- e) recognize demagnetization equipment.

4.2 Given a demonstration and explanation of equipment operations, the student will be able to:
- a) recognize the different controls and identify their function;
- b) operate the different types of equipment properly and safely;
- c) state the maintenance procedures for each type of equipment.

4.3 Given a demonstration and explanation of accessories, the student will be able to:
- a) distinguish between the types of contact points and their application;
- b) recognize magnetic field measurement equipment, test pieces for calibration and control vessels for wet bath concentration;
- c) recognize lamps for ultraviolet light and describe their proper use.

METHODOLOGICAL STRATEGIES:

Instructor's explanations using lecture method, demonstrations, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Equipment for magnetization, particles, magnetizable test pieces,
Equipment for demagnetization,
Accessories including various types of contact points, graduated test vessel, field indicators, ultraviolet lamps, protective hoods.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

SPECIFIC OBJECTIVES:

5.1 Given a set of written instructions, the student will be able to:
a) interpret the instructions correctly, perform the test on the appropriate work piece;
b) explain the differences between the techniques of wet and dry methods in relation to the conditions of application, size and form of the particles and the sensitivity of the test.

5.2 Given the demonstration and explanation and the liquids and particles, the student will be able to:
a) prepare colored and fluorescent particle suspensions in the appropriate concentrations;
b) compare these concentrations to standards or recommended practices.

METHODOLOGICAL STRATEGIES:

Instructor's explanations and demonstrations, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Examples of written instructions for magnetic particle testing,
Different types of equipment and work samples of different geometrical shapes and dimensions,
Fluorescent and coloured particles,
Water and oil suspension vehicles,
Vessel for measuring bath concentration,
Ultraviolet lamp, Safety hoods,
Power Point/Transparencies and Slides/Videos.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

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

SPECIFIC OBJECTIVES:

5.3 Given the necessary test conditions and equipment, the student will be able to:
- a) determine the existence and direction of the magnetic field, using field indicators;
- b) determine the existence of a remnant field;
- c) perform demagnetization using various systems in each case, checking afterwards for the presence of a remnant field.

5.4 Given the instructor's explanation and a selection of documents, the student will be able to recognize the different specifications and standards which govern the application of magnetic testing.

METHODOLOGICAL STRATEGIES:

Instructor's explanations and demonstrations guided discussion and practice.

EQUIPMENT AND RESOURCES:

Magnetization and demagnetization equipment, Work pieces of different sizes and shapes, Field indicators, Field measuring instruments, Power Point/Transparencies and Slides/Videos.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1
SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS

CONTENTS:

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

SPECIFIC OBJECTIVES:

6.1 Given an explanation and a number of practical examples, the student wi11 be able to correctly complete the appropriate test report forms.
6.2 Given the results of a magnetic particle test, the student will be able to:
  a) make a permanent record of the indications using photography;
  b) enter the results obtained on the appropriate report form.
6.3 Given the results of magnetic particle tests, the student wi11 be able to make a preliminary evaluation of the findings in accordance with the criteria contained in a written procedure.

METHODOLOGICAL STRATEGIES:

Instructor's explanations, guided discussion, practical exercises and written procedures.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Selection of forms, Samples, Test equipment,
Work pieces containing discontinuities,
Measuring equipment
Photographic camera and Adhesive tape.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2
SUBJECT: 2. PHYSICAL PRINCIPLES AND FUNDAMENTALS OF MAGNETIC PARTICLE TESTING

CONTENTS:

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

SPECIFIC OBJECTIVES:

2.1 Given the student's background knowledge and the instructor's explanation, the student will be able to:
  a) explain the concepts of current, voltage and resistance;
  b) relate these concepts to each other through Ohm's Law;
  c) distinguish between alternating current, direct current and half wave rectified current, with specific reference to their applications in magnetic particle testing.

2.2 Given the instructor's explanation and demonstrations, the student will be able to:
  a) distinguish between ferromagnetic, paramagnetic and diamagnetic materials;
  b) explain the concept of magnetism;
  c) distinguish between temporary and permanent magnets;
  d) explain the concepts of magnetic field, lines of force, magnetic poles and field distortion;
  e) define magnetic flux, magnetization force, reluctance and capacitive force with respect to a given hysteresis curve;
  f) illustrate magnetic field around a magnetic conductor, non-magnetic conductor and a solenoid, explain heat effects on magnetism;
  g) explain material hardness vs. magnetic retention.

2.3 Given the instructor's explanation and a specific hysteresis curve, the student will be able to determine the type of material to which it relates (high or low permeability).

2.4 Given the student's general understanding and the instructor's explanations, the student will be able to:

a) list the terms relating to electricity, magnetism, electromagnetism and to testing by magnetic particles, indicating the related abbreviations;
b) determine the saturation point, describing its characteristics;
c) measure the variation in permeability along the curve;
d) identify the point of maximum permeability;
e) determine the normal and tangential components of a vectorial representation of the magnetic field.

2.5 Given the student's background knowledge and the instructor's explanation, the student will be able to describe the characteristics of electromagnetic waves

2.6 Given the instructor's explanations, the student will be able to:
a) distinguish between visible and ultraviolet light;
b) explain the concept of fluorescence.

METHODOLOGICAL STRATEGIES:
Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Transparencies, writing board, samples, course notes, and slides.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2
SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

3.1 Methods of magnetization
- 3.1.1 Longitudinal
- 3.1.2 Circular

3.2 Magnetization techniques
- 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

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanation and demonstration, the student will be able to:
- a) distinguish between the methods of magnetization, determining direction of field and detectable defects;
- b) explain the basic principle of magnetization.

3.2 Given the instructor's explanation and demonstrations, the student will be able to:
- a) distinguish between field direction and distribution of the field in ferro- and paramagnetic materials when testing with passage of current;
- b) compare the technical differences, describing the limitations of each technique.

3.3 Given the instructor's explanation and demonstration, the student will be able to explain the difference between:
- a) permanent and remnant magnetism;
- b) testing by wet and dry methods.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, transparencies, slides, course notes, test pieces of different properties and dimensions, equipment and accessories for applying the test.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2
SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

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

3.5.3 Reasons for demagnetization
- a) operating conditions
- b) testing the effectiveness of demagnetization

SPECIFIC OBJECTIVES:

3.4 Given work pieces of different composition and dimensions, the student will be able to:
- a) select the most appropriate magnetization technique in each case, supporting this choice and specifying type of magnetization, method of applying the particles, type of current, field direction and calculation of current requirements
- b) determine the logical sequence of tests;
- c) carry out a magnetic test
- d) be aware of the safety requirements

3.5 Given the particles and the transport medium, the student will be able to:
- a) obtain the correct concentration both for coloured and fluorescent magnetic particles, considering the reasons for the difference with respect to the percentage of particles to be used;
- b) apply and compare the methods for checking sensitivity of a magnetic particle test, explaining the limitations of each;
- c) evaluate the magnetic properties of the particles used in the test;
- d) determine the conditions for and verification of demagnetization.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, transparencies, slides, course notes, test pieces of different properties and dimensions, equipment and accessories for applying the test and for demagnetization.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

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

Contact points; vessels for checking bath concentration; field indicators (Berthold test pieces); calibration pieces (JIS,ASTM,EN,MIL); magnetic field measurement equipment (Gaussmeter); ultraviolet lamps; colored and fluorescent powders; color for increasing contrast; morphology of the particles

4.3 Selection of equipment appropriate to the nature of the test

4.4 Special equipment : Portable equipment; stationary installations; automated equipment

---

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanation and various types of magnetization equipment, the student will be able to:

a) prepare a table comparing the equipment of the basis of testing capacity, type of current used, type and range of magnetic field, field of application, demagnetization capacity, particular structural characteristics, ease of use, handling and maintenance;
b) correctly perform adjustment and calibration of equipment.

4.2 Given the instructor's explanation and demonstration, the student will be able to:

a) recognize the types of contact points used, relating them to the work pieces in which they can be used;
b) use the various accessories correctly, including the vessels for checking bath concentration;
c) recognize the limitations on application of indicators and field measuring equipment;
d) compare coloured with fluorescent powders;
e) operate ultraviolet lamps properly, comparing the various types available;
f) determine the intensity requirements for ultraviolet lamps, describing how measurements are made.

4.3 Given the instructor's explanation, demonstration and a particular work piece, the student will be able to select the most suitable equipment for performing the test, depending on the characteristics of the work piece and type of defect to be detected.

4.4 Given the instructor's explanation and demonstration, the student will be able to compare portable and stationary equipment, identifying the advantages and 1imitations in each case and the conditions which must be met for using each type.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, test pieces of different properties and dimensions, equipment and accessories for applying the test.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2

SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

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
- 5.3.2 Internal specifications and corresponding standards
- 5.3.3 Codes and standards

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanation and a written test procedure, the student will be able to perform the test properly, interpreting the indications resulting from the procedure.

5.2 Given the instructor's explanation, the student will be able to:

a) interpret a procedure which would involve all the conditions under which the test must be carried out (equipment, current, field direction and intensity, type of particles);

b) determine the logical sequence for carrying out the test and the sequence for demagnetization;

c) compile instructions with sufficient detail for a level 1 operator to successfully carry out a magnetic particle test.

5.3 Given the instructor's explanations and the appropriate documents, the student will be able to distinguish between codes and standards used in NDT, especially in magnetic particle testing, both for performing the test and for the qualification and certification of personnel conducting the test.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, writing board, course notes, test pieces of various dimensions, equipment and accessories for applying the test, written test procedures, codes and standards relating to the tests, codes and standards relating to NDT qualification and certification.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2
SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS

CONTENTS:

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
   e)

SPECIFIC OBJECTIVES:

6.1 Given the results of the test he has conducted, the student will be able to present a report showing all aspects of the inspection process and the results obtained.
6.2 Given the instructor's explanation, the student will be able to design and complete an inspection report sheet in accordance with requirements and the inspection results.
6.3 Given the instructor' explanation, the student will be able to:
   a) distinguish between the different means of recording information and compare their limitations and applications;
   b) record the results of his own inspection using each of the different recording systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board, Course notes,
Test pieces of various dimensions,
Equipment and accessories for applying the test,
Written test procedures, codes and standards relating to the tests,
Photographic camera, Adhesive tape, and Other recording media.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2
SUBJECT: 7. INTERPRETATION OF RESULTS, LIMITATIONS OF THE METHOD

CONTENTS:

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

---

SPECIFIC OBJECTIVES:

7.1 Given a work piece of known characteristics and the corresponding procedure, the student will be able to:
  a) choose an appropriate procedure and determine the thresholds of the inspection;
  b) carry out the inspection of the work piece interpreting correctly the results obtained and determining whether the findings correspond to real discontinuities or whether they are spurious indications;
  c) evaluate the findings in accordance with the inspection criteria.
7.2 Given the instructor's explanation and the samples provided, the student will be able to relate the findings to defects inherent in the process of fabricating the test piece.
7.3 Given the instructor's explanation, the student will be able to determine the application and limitation magnetic particle testing.
7.4 Given the instructor's explanation, the student will be able to compare magnetic particle testing to other methods for detecting surface and subsurface flaws.
7.5 Given the instructor's explanations, the student will be able to:
  a) organize and administer the performance of tests with an NDT method with proper consideration of the safety of personnel and facilities;
  b) organize the tasks of staff involved in NDT to ensure the operation is conducted safely and efficiently.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, test pieces of various dimensions, equipment and accessories for applying the test, written test procedures,

codes and standards relating to the tests, codes and standards relating to NDT qualification and certification.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE FOR LEVEL 3

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 2. PHYSICAL PRINCIPLES AND FUNDAMENTALS OF MAGNETIC PARTICLES

CONTENTS:

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

SPECIFIC OBJECTIVES:

---

2. Given the instructor's explanations, the student will be able to:
   a) analyze and evaluate the theory of magnetic fields and magnetic induction in relation to the test method;
   b) make appropriate use of the laws of magnetism to perform the calculations required in applying the test;
   c) define the theoretical conditions required for the test in relation to the various techniques and the state of the specimen;
   d) determine and evaluate the conditions for the test;
   e) represent and calculate the magnetic field as a function of current and permeability and geometrical relations.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, delivery of support material, instructions explanations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, support material, and course notes.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

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
  - 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 Remanant 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

SPECIFIC OBJECTIVES:

---

3. Given the instructor's explanations, the student will be able to:
  - a) determine and discuss various testing techniques;
  - b) evaluate the applicability of the magnetization method in relation to defectology;
  - c) select and evaluate field intensity;
  - d) determine conditions for the use and calculate currents for the various techniques;
  - e) calculate current for magnetization by induction;
  - f) calculate current for magnetization by yokes and coils;
  - g) understand the effect of the air gap in yokes and permanent magnets and coil magnetization;
  - h) select the suitable demagnetization technique;
  - i) determine the suitability and effectiveness of demagnetization.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, delivery of support material, guided discussion and practical work in performance of the test.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Course notes,
Work pieces of varying characteristics and dimensions

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

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 technique of the test use and the material examined

---

SPECIFIC OBJECTIVES:

---

3. Given the instructor's explanations, the student will be able to:
   a) determine and discuss various testing techniques;
   b) evaluate the applicability of the magnetization method in relation to defectology;
   c) select and evaluate field intensity;
   d) determine conditions for the use and calculate currents for the various techniques;
   e) calculate current for magnetization by induction;
   f) calculate for magnetization by yokes and coils;
   g) know the effect of the air gap in yokes and permanent magnets and coil magnetization;
   h) select the suitable demagnetization technique;
   i) determine the stability and effectiveness of demagnetization.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, delivery of support material, guided discussion and practical work in performance of the test.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Course notes,
Work pieces of varying characteristics and dimensions.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

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
  - 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.

SPECIFIC OBJECTIVES:

---

4. Given the instructor's explanations, the student will be able to:
   - a) select and evaluate the equipment and accessories required for the various techniques;
   - b) make a comparative analysis of the magnetization capacity of the equipment;
   - c) evaluate the applicability of the various field measurement accessories in relation to the technique applied;
   - d) select and evaluate the means of indication, determining the conditions for their appropriate use;
   - e) select and evaluate demagnetization equipment;
   - f) design components and accessories for the application of magnetization current in unusual situations;
   - g) design and direct the installation and adjustment of test systems for production line monitoring.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, delivery of support material, teacher's explanations, guided discussions, demonstration, practice in selection and checking equipment.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Various magnetization equipment, Test pieces, Field measurement instruments, UV measurements, Standards and codes.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

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 Procedures
  5.3.1 Formulation of test procedures
  5.3.2 General and specific procedures

SPECIFIC OBJECTIVES:

---

5. Given the instructor's explanations, (and performance of the assigned exercises) the student will be able to:
   a) interpret, analyze and explain examination specifications produced by design engineers or laid down by codes;
   b) analyze, evaluate and formally complete test procedures, considering the type of specimen to be examined and the magnetic particle technique required, interpreting the specifications involved;
   c) analyze, interpret and discuss the validity of the procedures in relation to applicable specifications, codes and standards.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical assignment including the use of specifications and standards, discussion and analysis of procedures and formulation of test procedures.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Samples of design specifications, Standards and codes, Samples of general and specific procedures.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS

CONTENTS:

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

SPECIFIC OBJECTIVES:

6.1 Given the results of the test he has conducted, the student will be able to develop a report showing al1 aspects of the inspection process and the results obtained.
6.2 Given the instructor's explanation, the student will be able to design and complete an inspection report sheet in accordance with requirements and the inspection results.
6.3 Given the instructor's explanation, the student will be able to:
  a) distinguish between the different means of recording information and compare their limitations and applications;
  b) record the results of his own inspection using each of the different recording systems.
  c)

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Transparencies, Power Point/Transparencies, Slides/Videos, Course notes, Test pieces of various dimensions, Equipment and accessories for applying the test,
Written test procedures, codes and standards relating to the tests,
Photographic camera, Adhesive tape, Other recording media.

INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3
SUBJECT: 7. INTERPRETATION OF RESULTS, LIMITATIONS

CONTENTS:

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

---

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanation and the results of the inspection, the student will be able to present the results obtained in an ordered and logical manner.
7.2 Given a work piece of known characteristics and the corresponding procedure, the student will be able to:
   a) choose an appropriate procedure;
   b) determine the thresholds of the inspection;
   c) carry out the inspection of the workpiece interpreting correctly the results obtained and determining whether the findings correspond to real discontinuities or whether they are spurious indications;
   d) evaluate the findings in accordance with the inspection criteria.
7.3 Given the instructor's explanation and the samples provided, the student will be able to relate the findings to defects inherent in the process of fabricating the test piece.
7.4 Given the instructor's explanation, the student will be able to determine the application and limitation of testing by magnetic particles and to compare magnetic particle testing to other methods for detecting surface and subsurface flaws.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, test pieces of various dimensions, equipment and accessories for applying the test, written test procedures, codes and standards relating to the tests, codes and standards relating to NDT qualification and certification.

7. V. INSPECTION METHOD: LIQUID PENETRANT TESTING

SUBJECT	HOURS OF TRAINING		
	LEVEL l	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	5	[1)]
2. PHYSICAL PRINCIPLES OF THE TEST	3	3	2
3. PROCESSING	4	4	3
4. TEST EQUIPMENT AND MATERIALS	2	3	3
5. CODES, STANDARDS, PROCEDURES AND SAFETY	1	3	8
5 PRESENTATION AND RECORDING OF RESULTS	2	2	2
6. INTERPRETATION OF RESULTS LIMITATIONS	-	4	2
TOTAL	16	24	20[1)]

[1)] In addition to the above 20 hours a general knowledge common core course for level 3 (applicable to all NDT methods) is recommended, which shall be successfully completed only once.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

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
  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

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:
  a) define the physical principles on which the test is based;
  b) list the stages of application of the liquid penetrant method.
2.2 Given the instructor's explanations, the student will be able to:
  a) list the properties which must be met by liquid penetrants;
  b) indicate the influence exerted on the properties of the penetrating liquids by the surface state of the work piece, contamination, temperature of the work piece and the liquid.
2.3 Given the concepts of solution, dispersion and emulsification, the student will be able to:
  a) distinguish between them;
  b) list some substances which are used as solvents, dispersive agents and emulsifiers in penetrating liquids.
2.4 Given the instructor's explanations, the student will be able to:
  a) define the nature of the development processes with respect to penetrating liquids;
  b) list the forms of developer penetration and the granulometry of the powder in each case.

METHODOLOGICAL STRATEGIES:

Instructor's explanation including lecture, guided discussion and practical demonstration.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, chemical products, penetrants, work pieces.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

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

SPECIFIC OBJECTIVES:

2.5 Given the instructor's explanations, the student will be able to:
  a) define the coloured and fluorescent penetrants, determining the basic difference between them;
  b) indicate the difference in wavelength and the characteristics between white 1ight and UV radiation.
2.6 Given the instructor's explanations, the student will be able to recognize the difference in composition of liquids with an oily base and those with a non-oily base.
2.7 Given the instructor's explanations, the student will be able to:
  a) list the types of excess penetrant removers which are used in accordance with the techniques employed;
  b) recognize the composition and properties of the different types of removers.
2.8 Given the instructor's explanations, the student will be able to list the various types of developer applications, in accordance with the technique used, stating in each case its composition and state.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos and Examples of penetrant materials.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 3. PROCESSING

CONTENTS:

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

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations and a work piece, the student will be able to:
- a) perform a visual inspection to determine its surface state;
- b) identify the work piece in accordance with instructions;
- c) report on temperature.

3.2 Given the instructor's explanations, the student will be able to:
- a) list the various cleaning systems explaining in each case the type of impurity or contaminant which they can remove;
- b) list the mechanical cleaning media, stating the conditions which permit their use and the limitations of these media;
- c) perform the cleaning of work pieces, following written instructions.

3.3 Given the instructor's explanations, the student will be able to:
- a) list the forms of drying;
- b) recognize the time and temperature limits in accordance with the standards;
- c) carry out drying of a work piece in accordance with the instructions.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including guided discussion and practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, work pieces with different surface states and contaminants, work pieces with various contaminants (dust, fat, oil, oxides, scale, etc.), different types of cleaners, work pieces which have previously been cleaned, cold and

hot air dryers.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 3. PROCESSING

CONTENTS:

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
  3.6.2 Previous treatment of the developer

SPECIFIC OBJECTIVES:

3.4 Given the instructor's explanations, the student will be able to:
  a) describe the types of penetrant applications;
  b) define penetration times in accordance with standards;
  c) perform the correct application of a penetrant to a clean and dry work piece;
  d) select the established penetration temperature and time, in accordance with penetration time and temperature written instructions.

3.5 Given the instructor's explanations, the student will be able to:
  a) list the systems for removal of excess penetrant, explaining the relationship with the type of penetrant used;
  b) perform the removal of excess penetrant properly, applying the precautions and fulfilling the requirements necessary to avoid overwashing or insufficient removal, following a written procedure;
  c) perform subsequent drying of the work piece if required by the procedure.

3.6 Given the instructor's explanations, the student will be able to:
  a) list the various types of developer application;
  b) list the characteristics of a good developer;
  c) explain the importance of developer distribution;
  d) carry out the correct application of the developer, following a written procedure.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including guided discussion and practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, written instructions for liquid penetrant testing, work piece, penetrant and accessory equipment, drying material, work pieces (from which the excess penetrant has been removed)

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 3. PROCESSING

CONTENTS:

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
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

SPECIFIC OBJECTIVES:

3.7 Given the instructor's explanations and written instructions, the student will be able to:
- a) determine the conditions for observation, differentiating between them on the basis of whether the liquids are colored or fluorescent;
- b) observe the indications following the observation sequence;
- c) list the causes of false and/or irrelevant indications.

3.8 Given the instructor's explanations, the student will be able to explain the procedure and importance of final cleaning.

3.9 Given written instructions, the student will be able to note on the recording forms, the indications obtained in the test, showing graphically their location on a diagram of the work piece

---

METHODOLOGICAL STRATEGIES:

Instructor's explanations including guided discussion and practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Written instructions for liquid penetrant testing.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 4. TEST EQUIPMENT AND MATERIALS

CONTENTS:

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
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)

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations and a sample work piece, the student is able to:
  a) list the parameters which are checked in order to ensure the suitability of the materials used in the test, describing how this check is performed;
  b) compare the sensitivity of the test, carrying out every stage.
4.2 Given the systems of cleaning, the student will be able to recognize their proper state and operation.
4.3 Given various types of pulverizers and aerosols, the student will be able to test the effectiveness of the system and proper condition of the equipment.
4.4 Given the instructor’s explanations, the student will be able to:
  a) distinguish between portable equipment and stationary equipment for immersion;
  b) recognize each of the sections of the equipment and its use.
4.5 Given the instructor's explanations, the student will be able to:
  a) recognize various types of lighting equipment;
  b) explain positioning and measurement.
4.6 Given various ultraviolet lamps, the student will be able to:
  a) recognize the type of lamp and its efficiency characteristics.
  b) measure the intensity of ultraviolet radiation, using a suitable measuring instrument.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including guided discussion and practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Slides/Videos, penetrants, removers, developers, sample of work pieces, ultrasonic cleaning equipment and degreasing steam, aerosols, lighting equipment, tanks, accessories and materials, measurement devices for lighting, ultraviolet lamps.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 1
SUBJECT: 5. CODES, STANDARDS, PROCEDURES AND SAFETY

CONTENTS:

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

SPECIFIC OBJECTIVES:

5.1 Given the various classification of liquid penetrants processes in accordance with standards, the student will be able to prepare a table classifying the techniques in accordance with various standards, explaining the relationship between them.
5.2 Given the instructor's explanations, the student will be able to describe the safety conditions under which the test with liquid penetrants should be carried out.
5.3 Given written instructions, the student will be able to:
  a) perform the test, properly interpreting the instructions for it;
  b) fill out the test forms and note the results.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Codes covering liquid penetrants, Procedures, Equipment and Work pieces.

INSPECTION METHOD: PENETRANT TESTING LEVEL: 1
SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS

CONTENTS:

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

SPECIFIC OBJECTIVES:

6.1 Given an explanation and a number of practical examples, the student will be able to correctly complete the appropriate test report forms.
  6.2.1 Given the results of a penetrant test, the student will be able to:
    a) make a permanent record of the indications using photography;
    b) enter the results obtained on the appropriate report form.
6.3 Given the results of penetrant tests, the student will be able to make a preliminary evaluation of the findings in accordance with the criteria contained in a written procedure.

METHODOLOGICAL STRATEGIES:

Instructor's explanations, guided discussion, practical exercises and written procedures.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Selection of forms, Samples, Test equipment, Work pieces containing discontinuities, Measuring equipment, Photographic camera, and Adhesive tape.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: See common Basic for GENERAL KNOWLEDGE

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.3 Processing and defects
- 1.3.1 Primary processes and related defects
- 1.3.2 Manufacturing processes and related defects:
  - a) Casting processes and associated discontinuities: Ingots, blooms, and billets; Sand casting; Centrifugal casting; Investment casting
  - b) Wrought processes and associated discontinuities: forgings; rolled products; extruded products
  - c) Welding processes and associated discontinuities: submerged arc welding (SAW); shielded metal arc welding (SMAW); gas metal arc welding (GMAW); flux cored arc welding (FCAW); gas tungsten arc welding (GTAW); resistance welding; special welding processes — electron beam, electrogas etc.

1.4 Materials in service
- 1.4.1 Behaviour of materials in service
- 1.4.2 Service conditions leading to defects and failures: corrosion; creep; fatigue; wear; overload; brittle fracture, erosion, others
- 1.4.3 Concepts of rupture development in metals

1.5 Quality and standardization
- 1.5.1 Definition of quality, quality control and standardization
- 1.5.2 Development of a quality system
- 1.5.3 Examination, testing and inspection
- 1.5.4 Standards, codes, specifications and procedures
- 1.5.5 Protocols, records and reports

SPECIFIC OBJECTIVES:

1.3 Given the instructor's explanations, the student will be able to:
- a) describe the common primary metallurgical processes and the related defects;
- b) describe the common manufacturing processes and the related defects.

1.4 Given the instructor's explanations, the student will be able to:
- a) describe basic mechanisms giving rise to defects when the component is in service;
- b) describe defects that could arise during service and the general significance of each.

1 5 Given the instructor's explanations, the student will be able to:
- a) describe the basic concepts of quality and standardization;
- b) list the basic elements of a quality system;
- c) explain the basic premise of administration of information in a quality system.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, development from student experience and guided discussion of examples.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, films, writing board, course notes, Samples of materials and defects, Typical documents i.e. codes.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

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
  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

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to list the stages involved in application of the method.
2.2 Given the instructor's explanations, the student will be able to:
  b) identify the properties determining the behavior of liquids in contact with solids; explain the behavior of liquid penetrants in various stages of the process:
  c) explain the factors affecting the behavior of the liquids during the test;
2.3 Given the instructor's explanations, the student will be able to state the characteristics of solutions and emulsions;
2.4 Given the instructor's explanations, the student will be able to explain the differences in behavior between lipophilic and hydrophilic emulsifiers.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, experiments to demonstrate physical phenomena involved in the test, practical demonstration of the various stages of the test under supervision and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, work pieces illustrating different surface states and different materials, work pieces with calibrated fissures, penetrants for the various techniques for applying the test, and course notes.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

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
- 2.7.3 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

SPECIFIC OBJECTIVES:

2.5 Given the instructor's explanations, the student will be able to:
- a) explain the mechanism of development and the behavior of development powders in the dry state and in liquid suspension;
- b) explain the phenomena of colour and fluorescence;
- c) describe the behavior of fluorescent dyes and pigments in solutions.

2.6 Given the instructor's explanations, the student will be able to list the basic components of liquid penetrants and describe the influence of formulation on their behavior.

2.7 Given the instructor's explanations, the student will be able to:
- a) list the various types of removers and explain their behavior;
- b) list the various types of emulsifiers and explain the mechanisms of emulsification.

2.8 Given the instructor's explanations, the student will be able to explain the composition, granulometry and behavior of the developers.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussions.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, samples of penetrant and cleaning materials.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 3. PROCESSING

CONTENTS:

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

3.3.1 Use of cold and hot air

3.3.2 Temperature and time

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to state the requirements for treatment and identification of the work pieces to be tested.

3.2 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to explain the operating conditions required for the materials used in the proper application of the various techniques involving 1iquid penetrants, including the stage of pre-cleaning.

3.3 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to describe the use of various drying procedures.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical application of the test to selected work pieces for teaching purposes, analysis and discussion of the test results and practice in writing reports.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, laboratory for testing with penetrating liquids, equipped for applying the 6 standardized techniques.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 3. PROCESSING

CONTENTS:

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
- 3.5.3 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

---

SPECIFIC OBJECTIVES:

3.4 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to explain the application of liquid penetrants to carry out a valid inspection.

3.5 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to describe the conditions required for the observation, interpretation and recording of the indications.

3.6 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to interpret, evaluate and record the findings of the test in accordance with the written procedures.

3.7 Given the instructor's presentation, the student will be able to explain liquid penetrant methods for leak detection.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and supervised practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Penetrant equipment and supplies,
Samples, photographic equipment,
Report forms

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 4. TEST EQUIPMENT AND MATERIALS

CONTENTS:

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
  - 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
- 4.2.2 Ultrasonic

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations and performance of practical tasks, the student will be able to:
  - a) explain the requirements for evaluation of materials used in the tests;
  - b) state the main properties which have to be evaluated and describe the methods applicable;

4.2 Given the instructor's explanations and supervised practice, the student will be able to describe the use of ultrasonic cleaners and vapour degreasing equipment.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Brochures and diagrams of facilities and equipment, Instrumentation for measuring and sample work pieces.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 4. TEST EQUIPMENT AND MATERIALS

CONTENTS:

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 install ations

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

4.6 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

---

SPECIFIC OBJECTIVES:

4.3 Given the instructor's explanations, the student will be able to describe the various means of coupling developer materials.

4.4 Given the instructor's explanations and performance of practical tasks, the student will be able to describe the facilities and equipment in common use and the procedures applicable for their verification and maintenance.

4.5 Given the instructor's explanations, the student will be able to describe the types of light sources used and the equipment used to verify them.

4.6 Given the instructor's explanations, the student will be able to state the characteristics and conditions for the use of standardized work pieces for evaluating test procedures.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, equipment and test pieces.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 2
SUBJECT: 5. CODES, STANDARDS, PROCEDURES AND SAFETY

CONTENTS:

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

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

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations and the performance of practical exercises, the student will be able to:
- a) state classification systems of the techniques for application of liquid penetrants according to the standards in force,
- b) explain the criteria for application of liquid penetrants according to the standards in force;

5.2 Given the instructor's explanations and the performance of practical exercises, the student will be able to:
- a) interpret general and specific test procedures for liquid penetrants;
- b) develop test instructions for level 1;
- c) formulate the information required for documenting the test and presenting reports.

5.3 Given the instructor's explanations and the performance of practical exercises, the student will be able to recognize the qualification and certification standard for NDT personnel in force in his respective country;

5.4 Given the instructor's explanations and discussion of the subjects, the student will be able to:
- a) describe the risks inherent in the use of chemical and inflammable products;
- b) describe the risks involved in using UV radiation;
- c) list the applicable safety standards;
- d) prepare safety instructions for application of the test;
- e) describe the risks of environmental contamination

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, supervised practice and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Samples of standards and codes,
Comparative tables,
Course notes,
Safety equipment

INSPECTION METHOD: PENETRANT TESTING LEVEL: 2
SUBJECT: 7. INTERPRETATION OF RESULTS, LIMITATION

CONTENTS:

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 penetrant testing and other methods of testing for surface 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

---

SPECIFIC OBJECTIVES:

7.1 Given a work piece of known characteristics and the corresponding procedure, the student will be able to:
  a) choose an appropriate procedure and determine the thresholds of the inspection;
  b) carry out the inspection of the work piece interpreting correctly the results obtained and determining whether the findings correspond to real discontinuities or whether they are spurious indications;
  c) evaluate the findings in accordance with the inspection criteria.
7.2 Given the instructor's explanation and the samples provided, the student will be able to relate the findings to defects inherent in the process of fabricating the test piece.
7.3 Given the instructor's explanation, the student will be able to determine the application and limitation of testing by penetrant particles.
7.4 Given the instructor's explanation, the student will be able to compare penetrant testing to other methods for detecting surface flaws.
7.5 Given the instructor's explanations, the student will be able to:
  a) organize and administer the performance of tests with and NDT method with proper consideration of the safety of personnel and facilities;
  b) organize the tasks of staff involved in NDT to ensure the operation is conducted safely and efficiently.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, transparencies, slides, course notes, test pieces of various dimensions, equipment and accessories for applying the test, written test procedures, codes and standards relating to the tests, codes and standards relating to NDT qualification and certification.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE FOR LEVEL 3

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Review of physical, chemical and physico-chemical principles for applying the method. Liquid- solid interface phenomena
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, colour and contrast, systems of weighing units and thresholds

---

SPECIFIC OBJECTIVES:

-

2.1 Given the instructor's explanations, the student will be able to explain the mechanisms involved in the phenomena of the liquid -solid interface;
2.2 Given the instructor's explanations, the student will be able to analyze, evaluate and apply knowledge of the properties and mechanisms involved in every stage of the application of the method;
2.3 Given the instructor's explanations, the student will be able to analyze, evaluate and compare the various techniques for application of the method depending on the parameters of the products used and the material being tested;
2.4 Given the instructor's explanations, the student will be able to describe, analyze and evaluate the lighting conditions required for observation of the indications correlating lighting sources with the properties of heat and visual sensitivity;
2.5 Given the instructor's explanations, the student will be able to analyze, evaluate and determine the requirements for excitation with ultraviolet radiation for the use of fluorescent penetrating liquids.
2.6 Given the instructor's explanations, the student will be able to define the conditions for proper viewing of results.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including analysis of the graphic expression of the laws and principles of application, guided discussion and laboratory experiments.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, tables and graphs, laboratory material for demonstration of physicochemical principles, course notes.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 3. PROCESSING

CONTENTS:

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
3.3.5 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

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to select test techniques in accordance with the design specifications and the state and type of specimen to be tested,
3.2 Given the instructor's explanations, the student will be able to analyze, evaluate and determine the requirements for the identification, treatment and pre-cleaning of the specimens to be tested;
3. 3 Given the instructor’s explanations, the student wil1 be able to evaluate, settle and apply various methods of applying the penetrant to specimens of different configurations.
3.4 Given the instructor's explanations, the student will be able to select and evaluate effective penetrant removal systems.
3.5 Given the instructor's explanations, the student will be able to select and evaluate various developer systems.

3.6 Given the instructor's explanations, the student will be able to define and evaluate the necessary conditions for proper inspection and adequate interpretation of results.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including practical testing work on selected specimens, guided discussion of all stages of application of the test and the results.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Laboratory equipment and accessories for testing,
Products for the various testing techniques,
Specimens for testing.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 3. PROCESSING

CONTENTS:

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
- 3.7.4 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

SPECIFIC OBJECTIVES:

3.7 Given the instructor's explanations, the student will be able to define and evaluate the sensitivity of the technique applied;

3.8 Given the instructor's explanations, the student will be able to define and evaluate operating conditions for the application of various stages of the test taking into consideration design specifications, type of specimen, work- environment conditions, industrial safety and economic factors;

3.9 Given the instructor's explanations, the student will be able to define and evaluate various penetrant techniques for leak detection.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including practical testing work on selected specimens and guided discussion of the stages of applications of the test and the results.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Laboratory, equipment and accessories for testing, Products for the various testing techniques and Specimens for testing.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 4. TEST EQUIPMENT AND MATERIALS

CONTENTS:

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
- 4.2.1 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

---

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations and performance of the practical work and calculations, the student will be able to analyze, evaluate and select the various economically viable processes, depending on the requirements of the examination in question and the test conditions.

4.2 Given the instructor's explanations and performance of the practical work and calculations, the student will be able to: a) determine the requirements of testing and analysis applicable to control of the materials used in the test; b) select the type of work piece for evaluation suited to the processes to be used; c) determine suitable methods for rating the processes to be used.

4.3 Given the instructor's explanations and performance of the practical work and calculations, the student will be able to: a) evaluate, select and apply correctly the equipment and accessories corresponding to the application of the specific test techniques involved; c) select, install and adjust test installations for manual of automated testing in pi ants.

4.4 Given the instructor's explanations and performance of the practical work and calculations, the student will be able to check lighting equipment and accessories to determine suitability for use to meet established procedures.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including practical work on behavior test, practical work on the use of calibrated test pieces, discussion of results, guided visit to plants and works where the test is used.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos.
Laboratory with equipment, materials and suitable work pieces.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 5. CODES, STANDARDS, PROCEDURES AND SAFETY

CONTENTS:

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 Testing procedures
  5.3.1 Formulation of test procedures
  5.3.2 General and specific procedures
5.4 Safety in penetrant testing

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to interpret, analyze and apply specifications for examination prepared by design engineers or called for in codes of practice;
5.2 Given the instructor's explanations, the student will be able to analyze, evaluate and apply liquid penetrant testing according to national and international standards:
5.3 Given the instructor's explanations, the student will be able to develop, evaluate and apply written procedures for liquid penetrant testing, conforming to externally imposed requirements and those imposed by the specimens, equipment available and work environment.
5.4 Given the instructor's explanations, the student will be able to apply good safety practices in the application of penetrant testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and supervised practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Sample codes, standards, specifications and procedures.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS

CONTENTS:

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

SPECIFIC OBJECTIVES:

6.1 Given the results of the test he has conducted, the student will be able to develop a report showing al1 aspects of the inspection process and the results obtained.
6.2 Given the instructor's explanation, the student will be able to design and complete an inspection report sheet in accordance with requirements and the inspection results.
6.3 Given the instructor's explanation, the student will be able to:
   a) distinguish between the different means of recording information and compare their limitations and applications;
   b) record the results of his own inspection using each of the different recording systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board,
Course notes,
Test pieces of various dimensions,
Equipment and accessories for applying the test,
Written test procedures, codes and standards relating to the tests,
Photographic camera, Adhesive tape and other recording media.

INSPECTION METHOD: LIQUID PENETRANT TESTING LEVEL: 3
SUBJECT: 7. INTERPRETATION OF RESULTS, LIMITATIONS

CONTENTS:

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 penetrant testing and other methods of testing for surface and subsurface flaws

---

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanation and the results of the inspection, the student will be able to present the results obtained in an ordered and logical manner.
7.2 Given a work piece of known characteristics and the corresponding procedure, the student will be able to:
  a) choose an appropriate procedure;
  b) determine the thresholds of the inspection;
  c) carry out the inspection of the workpiece interpreting correctly the results obtained and determining whether the findings correspond to real discontinuities or whether they are spurious indications;
  d) evaluate the findings in accordance with the inspection criteria.
7.3 Given the instructor's explanation and the samples provided, the student will be able to relate the findings to defects inherent in the process of fabricating the test piece.
7.4 Given the instructor's explanation, the student will be able to determine the application and limitation of testing by liquid penetrants and to compare penetrant testing to other methods for detecting surface flaws.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and student practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, test pieces of various dimensions, equipment and accessories for applying the test, written test procedures, codes and standards relating to the tests, codes and standards relating to NDT qualification and certification.

8. VI. INSPECTION METHOD: EDDY CURRENT TESTING

SUBJECT	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	8	[1)]
2. PHYSICAL PRINCIPLES	8	4	4
3. INSTRUMENTATION	8	12	11
4. TESTING PROCEDURES	14	16	12
5. APPLICATIONS	4	20	11
6. RECORDING AND EVALUATION OF RESULTS	2	4	8
TOTAL	40	64	46 [1)]

[1)] In addition to the above 46 hours a general knowledge common core course for level 3 (applicable to all NDT methods) is recommended, which shall be successfully completed only once.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENT : SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT 2. PHYSICAL PRINCIPLES

CONTENTS:

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
  - 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

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanation and the student's knowledge of basic physics, the student will be able to define the terms associated with direct and alternating current.

2.2 Given the instructor's explanation, the student will be able to define the terms associated with magnetism and magnetic fields.

2.3 Given the instructor's explanation, the student will be able to define the terms associated with electromagnetism.

2.4 Given the instructor's explanation, the student will be able to describe the electrical and magnetic field associated with different shapes of interest in eddy current testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, worked examples and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, computer presentations,
Sample magnets and iron filings,
Selection of typical geometric shapes used in eddy current testing.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT: 3. INSTRUMENTATION

CONTENTS:

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

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanation, the student will be able to explain the principles and basic characteristics of eddy current probes.
3.2 Given the instructor's explanation, the student will be able to describe the reaction of the different types of coil to defects of various geometries.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Examples of eddy current probes of various configurations.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT: 3. INSTRUMENTATION

CONTENTS:

3.4 Working principles of eddy current equipment
- 3.4.1 Transmission
- 3.4.2 Reception
- 3.4.3 Data presentation

3.5 Adjustment of eddy current equipment
- 3.5.1 Frequency
- 3.5.2 Energizing device
- 3.5.3 Balance
- 3.5.4 Phase rotation
- 3.5.5 Output filter
- 3.5.6 Gain

3.6 Different types of eddy current equipment
- 3.6.1 Monoparameter and monochannel equipment
- 3.6.2 Specialized 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

SPECIFIC OBJECTIVES:

3.4 Given the instructor's presentation, the student will be able to explain the working principles of eddy current equipment.

3.5 Given the instructor's explanations, the student will be able to explain the functions of the various controls which are used to adjust the eddy current system.

3.6 Given the instructor's presentation, the student will be able to describe the different types of eddy current equipment.

3.7 Given the instructor's presentation, the student will be able to explain the types of auxiliary equipment commonly used and state the application of each.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, demonstration equipment.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT: 4. TESTING PROCEDURES

CONTENTS:

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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to describe the influence of defect position and orientation on the eddy current indication.
4.2 Given the instructor's explanations, the student will be able to describe the influence of temperature on the eddy current results.
4.3 Given the instructor's explanations, the student will be able to describe the effect of structure and geometry on the eddy current indications.
4.4 Given the instructor's explanations, the student will be able to explain the influence of coupling on the eddy current indications.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos,
Eddy current equipment and accessories, work pieces of various geometries and sizes.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT: 4. TESTING PROCEDURES

CONTENTS:

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

SPECIFIC OBJECTIVES:

4.5 Given the instructor's explanation, the student will be able to explain the function and use of reference standards.
4.6 Given the instructor's explanation, the student will be able to explain the inspection procedure including the recording of indications.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Eddy current equipment and accessories,
Work pieces of various geometries and sizes,
Reference standards.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT: 5. APPLICATIONS

CONTENTS:

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanation, the student will be able to describe the method for measuring product composition by measuring electrical conductivity.

5.2 Given the instructor's explanation, the student will be able to explain the means of thickness measurement by eddy currents.

5.3 Given the instructor's explanation, the student will be able to describe how defects are detected by eddy current testing.

5.4 Given the instructor's explanation, the student will be able to relate eddy current results to the origin of the discontinuity.

5.5 Given the instructor's explanation, the student will be able to explain how absolute and differential measurements are applied in eddy current testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussions.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Equipment and test pieces of various shapes and sizes containing defects.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 1
SUBJECT: 6. RECORDING AND EVALUATION OF RESULTS

CONTENTS:

6.1 Written instructions
6.2 Report preparation

SPECIFIC OBJECTIVES:

6.1 Given a written instruction and the instructor's explanation, the student will be able to carry out an eddy current inspection following written instructions.
6.2 Given a report chart and the instructor's explanation, the student will be able to write a clear and concise report of a test he has carried out.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and supervised practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Sample written instructions and associated test pieces, Eddy current equipment and Report forms.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENT : SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 2. PHYSICAL PRINCIPLES

CONTENTS:

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,
  - 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,
  - b) in a metallic mass,
  - c) skin effect,

d) field created by eddy current,
e) reactance

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanation and the student's knowledge of basic physics, the student will be able to define the terms associated with direct and alternating current.

2.2 Given the instructor's explanation, the student will be able to define the terms associated with magnetism and magnetic fields.

2.3 Given the instructor's explanation and the student's knowledge of basic physics, the student will be able to explain the Biot and Savart law and Ampere's law.

2.4 Given the instructor's explanation, the student will be able to explain the terms associated with Lenz's law and induced currents.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, worked examples and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos, sample magnets and iron filings.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 3. INSTRUMENTATION

CONTENTS:

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
- 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

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanation, the student will be able to explain the principles and operating characteristics of eddy current probes

3.2. Given the instructor's explanation, the student will be able to explain the distribution of eddy currents relative to coil position and to describe the methods of focusing eddy currents

3.3. Given the instructor's explanation, the student will be able to describe and explain the reaction of the different types of coil to defects of various geometries.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Examples of eddy current probes of various configurations.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 3. INSTRUMENTATION

CONTENTS:

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
- 3.5.7 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

SPECIFIC OBJECTIVES:

3.4 Given the instructor's explanation, the student will be able to explain the impact of technology and practice on the design of the probe.

3.5 Given the instructor's explanations, the student will be able to explain the main functions of the eddy current instrument and the controls which are associated with these functions.

3.6 Given the instructor's presentation, the student will be able to compare the different types of eddy current equipment and explain the most appropriate application for each.

3.7 Given the instructor's presentation, the student will be able to compare the types of auxiliary equipment commonly used and explain the application of each.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board or white board, transparencies, Power Point/Transparencies, Slides/Videos, examples of eddy current probes of various configurations, demonstration equipment.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 4. TESTING PROCEDURES

CONTENTS:

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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to describe and explain the influence of defect position and orientation on the eddy current indication.
4.2 Given the instructor's explanations, the student will be able to explain the influence of temperature on the eddy current results.
4.3 Given the instructor's explanations, the student will be able to explain the effect of structure and geometry on the eddy current indications.
4.4 Given the instructor's explanations, the student will be able to explain the influence of coupling on the eddy current indications.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos,
Eddy current equipment and accessories,
Work pieces of various geometries and sizes

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 4. TESTING PROCEDURES

CONTENTS:

SPECIFIC OBJECTIVES:

4.5 Given the instructor's explanation, the student will be able to explain the influence of probe speed relative to the part on the eddy current results.
4.6 Given the instructor's explanation, the student will be able to explain the function and use of reference standards.
4.7 Given the instructor's explanation, the student will be able to explain the inspection procedure, record the indications, and analyze and interpret the results.
4.8 Given the instructor's explanation, the student will be able to prepare a written instruction based on technical standards.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Eddy current equipment and accessories,
Work pieces of various geometries and sizes,
Sample written instructions and associated test pieces.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 5. APPLICATIONS

CONTENTS:

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
  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 permeability: chemical analysis, structure, grain size and texture influence

---

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanation, the student will be able to explain how defects of various sizes are characterized by eddy current results.
5.2 Given the instructor's explanation, the student will be able to explain the importance of various parameters on the production of the eddy current signal from a long conductive product.
5.3 Given the instructor's explanation, the student will be able to explain the use of impedance diagrams and the importance of the operating point.
5.4 Given the instructor's explanation, the student will be able to explain how the electromagnetic properties of materials influence the eddy current result.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussions.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Equipment and test pieces of various shapes and sizes containing defects.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 5. APPLICATIONS

CONTENTS:

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
- 5.6.3 Measuring by electrical conductivity
- 5.6.3 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

SPECIFIC OBJECTIVES:

5.5 Given the instructor's explanation, the student will be able to relate eddy current results to the origin of the discontinuity.

5.6 Given the instructor's explanation, the student will be able to explain the means of thickness measurement by eddy currents.

5.7 Given the instructor's explanation, the student will be able to describe the method for measuring product composition by measuring electrical conductivity and magnetic comparator.

5.8 Given the instructor's explanation, the student will be able to describe the method for weld inspection with a representative standard.

5.9 Given the instructor's explanation, the student will be able to explain the principles and applications of multi frequency eddy current test equipment.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussions.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos
Equipment and test pieces of various shapes and sizes containing defects
Equipment and test pieces of various thicknesses and with coatings
Test pieces for demonstration of conductivity testing
Test pieces for weld inspection

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 2
SUBJECT: 6. RECORDING AND EVALUATION OF RESULTS

CONTENTS:

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
6.6 Safety
6.6.1 Implementation of industrial safety standards in facilities and equipment

---

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanation, the student will be able to explain the contents of some typical codes and standards which govern the application of eddy current testing.
6.2 Given the instructor's explanation, the student will be able to check the equipment with a representative standard.
6.3 Given the instructor's explanation, the student will be able to apply specifications and procedures which are used in eddy current testing.
6.4 Given the instructor's explanation, the student will be able to develop inspection techniques for inspection problems to which the eddy current method applies.
6.5 Given the instructor's explanation, the student will be able to write clear and concise reports of tests he has carried out and evaluate reports prepared by others.
6.6 Given the instructor's explanation, the student will be able to apply industrial safety standards in using eddy current inspection techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and supervised practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Sample written procedures and associated test pieces, Eddy current equipment, Report forms
Codes, standards and specifications.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE FOR LEVEL 3

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 2. PHYSICAL PRINCIPLES

CONTENTS:

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
- 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 current distribution (amplitude, phase), standard penetration depth
- 2.4.2 Tubes, simplifying hypothesis, similarity law, different expressions of limit frequency, eddy current distribution, standard penetration depth
- 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

---

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanation and the student's knowledge of basic physics, the student will be able to explain the phenomena of electromagnetic induction

2.2 Given the instructor's explanation, the student will be able to explain the effect of a second circuit on the impedance of one circuit.

2.3 Given the instructor's explanation, the student will be able to explain the principles of electromagnetic wave propagation.

2.4 Given the instructor's explanation, the student will be able to explain the distribution of eddy currents in common and complex shapes.

2.5 Given the instructor's explanation, the student will be able to explain the impedance diagrams for special coil geometries.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, worked examples and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos,
Selection of shapes encountered in eddy current testing.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 3. INSTRUMENTATION

CONTENTS:

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
- 3.1.4 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 coil arrangements

3.3 Working principle of eddy current equipment
- 3.3.1 Transmission
- 3.3.2 Reception
- 3.3.3 Data presentation

SPECIFIC OBJECTIVES:

3.1 Given instructor's explanation, the student will be able to explain the principles and operating characteristics of eddy current probes.

3.2 Given the instructor's explanation, the student will be able to explain the differences in coupling and current distribution that results from the various types of coil arrangements.

3.3 Given the instructor's presentation, the student will be able to explain the working principles of eddy current equipment.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Examples of eddy current probes of various configurations,
Eddy current equipment.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 3. INSTRUMENTATION

CONTENTS:

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
- 3.5.1 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

SPECIFIC OBJECTIVES:

3.4 Given the instructor's explanations, the student will be able to explain the main functions of the eddy current instrument and the controls which are associated with these functions

3.5 Given the instructor's presentation, the student will be able to compare and evaluate the different types of eddy current equipment and explain the most appropriate application for each.

3.6 Given the instructor's presentation, the student will be able to compare the types of auxiliary equipment commonly used and explain the application of each.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos,
Eddy current equipment,
Demonstration equipment.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 4. TESTING PROCEDURES

CONTENTS:

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

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to describe and explain the influence of defect position and orientation on the eddy current indication.

4.2 Given the instructor's explanations, the student will be able to explain the influence of temperature on the eddy current results.

4.3 Given the instructor's explanations, the student will be able to explain the effect of structure and geometry on the eddy current indications.

4.4 Given the instructor's explanations, the student will be able to explain the influence of coupling on the eddy current indications.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos,
Eddy current equipment and accessories,
Work pieces of various geometries and sizes.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 4. TESTING PROCEDURES

CONTENTS:

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
- 4.7.2 Recording of indications
- 4.7.3 Analysis and interpretation of results

SPECIFIC OBJECTIVES:

4.5 Given the instructor's explanation, the student will be able to explain the influence of probe speed relative to the part on the eddy current results.

4.6 Given the instructor's explanation, the student will be able to explain the function and use of reference standards.

4.7 Given the instructor's explanation, the student will be able to explain the inspection procedure, record the indications, and analyze and interpret the results.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Eddy current equipment and accessories,
Work pieces of various geometries and sizes,
Reference standards.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 5. APPLICATIONS

CONTENTS:

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
- 5.2.2 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

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanation, the student wi11 be able to explain how the electromagnetic properties of materials influence the eddy current result.

5.2 Given the instructor's explanation, the student will be able to relate eddy current results to the origin of the discontinuity.

5.3 Given the instructor's explanation, the student will be able to explain how differential and absolute measurements are applied in eddy current testing.

5.4 Given the instructor's explanation, the student will be able to explain the means of thickness measurement by eddy currents.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussions.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Equipment and test pieces of various shapes and sizes containing defects.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 5. APPLICATIONS

CONTENTS:

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
  5.7.3 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

---

SPECIFIC OBJECTIVES:

5.5 Given the instructor's explanation, the student will be able to describe the method for measuring product composition by measuring electrical conductivity.
5.6 Given the instructor's explanation, the student will be able to explain the principles and applications of recently developed types of eddy current equipment.
5.7 Given the instructor's explanation, the student will be able to analyze problems and develop solutions to produce effective inspections with eddy current equipment.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations and guided discussions.

EQUIPMENT AND RESOURCES:

Writing board or white board, Power Point/Transparencies, Slides/Videos,
Equipment and test pieces of various thicknesses and with coatings,
Test pieces for demonstration of conductivity testing,
Equipment and test pieces of various geometries, sizes and characteristics.

INSPECTION METHOD: EDDY CURRENT TESTING LEVEL: 3
SUBJECT: 6. RECORDING AND EVALUATION OF RESULTS

CONTENTS:

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

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanation, the student will be able to evaluate, analyze and develop typical codes and standards to govern the application of eddy current testing.
6.2 Given the instructor's explanation, the student will be able to develop a written instruction that covers all parameters for checking the system to reach a high level of repeatability in the results of tests.
6.3 Given the instructor's explanation, the student will be able to analyze, evaluate and develop specifications and procedures to be used in eddy current testing.
6.4 Given the instructor's explanation, the student will be able to develop and evaluate inspection techniques for inspection problems to which the eddy current method applies.
6.5 Given the instructor's explanation, the student will be able to write clear and concise reports of tests he has carried out and evaluate reports prepared by others.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and supervised practical work

---

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Sample written procedures and associated test pieces,
Eddy current equipment,
Report forms, Codes, standards and specifications.

9. VII. INSPECTION METHOD: LEAK TESTING

SUBJECT	HOURS OF TRAINING								
	LEVEL 1			LEVEL 2			LEVEL 3		
	A[2)]	B[2)]	C[2)]	A[2)]	B[2)]	C[2)]	A[2)]	B[2)]	C[2)]
1. GENERAL KNOWLEDGE	1	-	-	2	-	-	[1)]	[1)]	[1)]
2. PHYSICAL PRINCIPLES OF THE TEST	3	-	-	4	-	-	4	-	-
3. TEST TECHNIQUES	-	6	6	-	20	20	-	13	14
4. EQUIPMENT AND ACCESSORIES	-	8	12	-	11	16	-	8	10
5. CODES, STANDARDS, PROCEDURES AND GUIDELINES	1	-	-	4	-	-	4	-	-
6. SAFETY ASPECTS	1	-	-	1	-	-	1	-	-
7. APPLICATIONS	1	-	-	3	-	-	1	-	-
8. DOCUMENTATION OF THE TEST	1	-	-	2	-	-	2	-	-
TOTAL	8[2)]	14[2)]	18[2)]	16[2)]	31[2)]	36[2)]	12[2)]	21[2)]	24[2)]

[1)] In addition to the above 40 hours a general knowledge common core course for level 3 (applicable to all NDT methods) is recommended, which shall be successfully completed only once..

[2)] A: Basic knowledge, B: Pressure method, C: Tracer gas method. The content to complete the required hours for each shall be selected by the instructor from the topics detailed for each subject

INSPECTION METHOD: LEAK TESTING **LEVEL: 1**
SUBJECT: 1. GENERAL KNOWLEDGE

SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: LEAK TESTING **LEVEL: 1**
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Type of gases, properties and behavior of gases, general equation of gases, pressurization of gases, temperature effects, variations in atmospheric pressure and changes in vapor pressure, definition of pressure, measuring of vapor pressure, pressure units, volume and flow rate units used in leak testing

2.2 Basic knowledge of leaks and leakage, real and virtual leaks, leak conductance, sensitivity of a detector and sensitivity of test, leakage measurement, outgassing phenomena

2.3 Basic knowledge of tracer fluids

SPECIFIC OBJECTIVES:

2.1 Given the instructor’s explanations, the student will be able to:
   a) list the general properties and behaviour of gases;
   b) describe the units applicable to the measurement of flow-rate, volume and pressure of fluids.

2.2 Given the instructor's explanations, the student will be able to recognize the difference between real and virtual leaks.

2.3 Given the instructor's explanations, the student will be able to recognize the usefulness of tracer fluids.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Films and Course notes

INSPECTION METHOD: LEAK TESTING **LEVEL: 1**
SUBJECT: 3. TEST TECHNIQUES

CONTENTS:

3.1 Techniques for the application of leak testing
- a) Bubble testing
- b) Pressure change measurement
- c) Halogen detection
- d) Helium detection
- e) Radioactive tracers
- f) Liquid penetrants and chemical tracers
- g) Ultrasonic leak testing; acoustic emission leak testing
- h) Vacuum box testing
- i) Halide torch testing
- j) High voltage discharge testing
- k) Light absorption testing; thermal conductivity leak testing
- l) Gas analysis (gas chromatography, residual gas analysis)

3.2 Leaks detection, location of leaks and leakage measurements, operative conditions for dynamic and static tests

3.3 Bubble test: operative conditions for bubble test and foam test, conditioning of liquid for bubbling, solutions for formation of foam, examination of seamed tubes and welded vessels, check of locks and gates, operative conditions for testing systems of reference, relative terminology, gas pressurization, effects of changes in temperature, vapour pressure and atmospheric pressure, application to examination of piping and vessels, advantages and limitations

3.4. Pressure change measurement, principles of pressure change method, pressurization and evacuation modes, pumping methods, observation techniques, pumping pressures, outgassing problems, pressure and vacuum analyses, advantages and limitations

3.5 Test by detection of halogens, operative conditions for leak test using halogen diode detector, operation principles, relative terminology, operation and maintenance of halogen detectors, application of standard leaks, halogen percentage in tracer fluid, head effects in R-12 fluid, contamination measurement, calibration, standards and sensitivity, atmosphere control, halogen vapor, advantages and limitations

3.6 Test with helium spectrometers, probing speed, operative conditions for leak test with helium spectrometer, operation and maintenance of helium mass spectrometers, calibration for different tests, operation of vacuum pumps, test techniques, outgassing vs. pressure, percentage of helium in tracer fluid, sniffing techniques, use of sniffers, diameter and length of sniffing hose, pressure differential, technique with accumulation in bags dynamic method with use of probe and bag static method, pressure system, advantages and limitations

3.7 Further and advanced techniques

3.7.1 Radioactive tracers, applicability and principle of test, krypton-85 gas, advantages and limitations

3.7.2 Liquid penetrants and chemical tracers, applicability and characteristics of techniques, penetrant materials, ammonia gas leak test, carbon dioxide tracer gas, chemical fumes leak detector, indicator solutions, advantages and limitations

---

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to define the different techniques used in leak detection and measurement.

3.2 Given the instructor's explanations, the student will be able to describe operating conditions for dynamic and static tests.

3.3 Given the instructor's explanations, the student will be able to:

a) describe the operative conditions for applying bubble tests;
b) prepare the solutions for bubbling and foaming tests;
c) apply the bubble test to different components;
d) operate testing in accordance with reference systems;
e) demonstrate knowledge of terminology; conditions for gas pressurization; effect of temperature changes and vapour pressure.

3.4 Given the instructor's explanations, the student will be able to:

a) know operating conditions for leak tests using pressure change method;
b) know the corresponding technology;
c) know operation and maintenance of pressure and vacuum pumps and accessories.

3.5 Given the instructor's explanations, the student will be able to:

a) know operating conditions for leak tests using halogen diode detectors;
b) know the corresponding technology;
c) know operation and maintenance of halogen detectors and use of leak standards.

3.6 Given the instructor's explanations, the student will be able to:

a) know operating conditions for leak tests using helium-mass spectrometer.
b) know the corresponding technology;
c) know the operation and maintenance of helium mass spectrometer and related vacuum systems;
d) know the use of different test techniques;
e) know the use of sniffers and the calibration of standard leaks.

3.7.1 Given the instructor's explanations, the student will be able to:

a) know fundamental principle of the test;
b) know the corresponding technology.

3.7.2 Given the instructor's explanations, the student will be able to:

a) know fundamental principles of the tests;
b) know the corresponding technology;
c) know the use of different test techniques

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, practical student development, guided discussion and development from student experience.

EQUIPMENT AND RESOURCES:

Writing board,
Power Point/Transparencies, Slides/Videos,
Course notes,
Pressure change measurement test
Equipment and accessories,
Halogen detection test equipment and accessories
Helium detection test equipment and accessories
Liquid penetrant consumables and accessories
Other applicable test equipment and accessories

CONTENTS:

3.7.3 Ultrasonic leak testing, principles, characteristics and applicability, advantages and limitations

3.7.4 Acoustic emission leak testing, fundamental principles of acoustic emission leak testing, applicability and characteristics of the test, methods of acoustic emission testing, advantages and limitations

3.7.5 Vacuum box leak testing, applicability and principle of test, advantages and limitations

3.7.6 Halide torch testing, principles and characteristics of technique, applicability of the test, advantages and limitations

3.7.7 High voltage discharge testing; principles of the test, white spark technique, colour differentiation technique, analysis and interpretation, applicability of the test, advantages and limitations

3.7.8 Light absorption testing; applicability and characteristics, principles and methods of operation, advantages and limitations

3.7.9 Thermal conductivity leak testing; applicability and characteristics, principles and methods of leak testing, advantages and limitations

3.7.10 Gas analysis; (gas chromatography, residual gas analysis), fundamental principles of the test, advantages and limitations

---

SPECIFIC OBJECTIVES:

3.7.3 Given the instructor's explanations, the student will be able to:
a) know fundamental principle of the test;
b) know the corresponding technology.

3.7.4 Given the instructor's explanations, the student will be able to:
a) know fundamental principle of the test;
b) know the corresponding technology.

3.7.5 Given the instructor's explanations, the student will be able to:
a) know fundamental principle of the test;
b) know the corresponding technology;
c) know the use of test technique.

3.7.6 Given the instructor's explanations, the student will be able to:
a) know the principle of the test;
b) know the corresponding technology.

3.7.7 Given the instructor's explanations, the student will be able to:
a) know principle of the test;
b) know the corresponding technology.

3.7.8 Given the instructor's explanations, the student will be able to:
a) know the principle of the test;
b) know the corresponding technology.

3.7.9 Given the instructor's explanations, the student will be able to:
a) know principle of the test;
b) know the corresponding technology;
c) know the use of test technology.

3.7.10 Given the instructor's explanations, the student will be able to:

a) know the principle of the test;
b) know the corresponding technology.

3.8 Given the instructor's explanations, the student will be able to interpret written instructions for conducting leak tests using different techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, practical student involvement, guided discussion and development from student experience.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Films,
Course notes,
Vacuum box leak test equipment and accessories,
Thermal conductivity leak test equipment and accessories,
Other applicable test equipment and accessories.

INSPECTION METHOD: LEAK TESTING **LEVEL: 1**
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.1 Applicators of foaming solutions; vacuum boxes, lighting devices
4.2 Instruments for the measurement of pressure, temperature and dew point, precision of instruments and calibration
4.3 Halogen diode detector, units for leak control, gun type detector, normalized leaks, electron capture
4.4 Helium- mass spectrometer, vacuum unit, control cabinet, spectrometer, sniffers, calibrated enclosure
4.5 Accessories; vacuum pumps, vacuum valves, vacuum pipes, vacuum connectors, cold traps, compound mastics for sealing to vacuum, calibrated leaks
4.5.1 Gauges; (assembly criteria and pressure reading techniques of all gauges), mechanical gauges (bourdon gauges and diaphragm gauges), u-tube manometers, Mcleod gauges, pirani gauges, thermocouple gauges, hot cathode ionisation gauges, cold cathode ionisation gauges
4.5.2 Pumps; (knowledge of maintenance & assembly criteria), rotary vane and rotary piston pump, oil diffusion pumps, liquid nitrogen traps

---

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations and demonstrations, the student will be able to understand the operation of foam applicators, vacuum boxes and lighting devices.
4.2 Given the instructor's explanations and demonstrations, the student will be able to understand the principle of operation and calibration of the instruments for measuring of pressure, temperature and dew point.
4.3 Given the instructor's explanations and demonstration, the student will be able to understand the characteristics of halogen diode detectors.
4.4 Given the instructor's explanations and demonstration, the student will be able to understand the characteristics of helium mass spectrometer and differentiate between its components.
4.5 Given the instructor's explanations and demonstration, the student will be able to recognize the different accessories employed in leak testing and be able to use them in accordance with given instructions.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and development from student experience.

EQUIPMENT AND RESOURCES:

Writing board, transparencies, films, course notes,
Equipment for different leak tests and accessories.

INSPECTION METHOD: LEAK TESTING LEVEL: 1
SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND GUIDELINES

CONTENTS:

5.1 General knowledge
- 5.1.1 National, regional and international codes and standards
- 5.1.2 General knowledge of specifications
- 5.1.3 Test performance following the established testing instructions prepared by level 2 or level 3 personnel

5.2 Instruction for the test
- 5.2.1 Interpretation

SPECIFIC OBJECTIVES:

5.1 Given the various classification of leak testing processes in accordance with standards, the student will be able to prepare a table classifying the techniques in accordance with various standards, explaining the relations between them.

5.2 Given the instructor's explanations, the student will be able to:

a) Perform the test, properly interpreting the instructions for it;
b) Fill out the test forms and note the results.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Course notes,
Leak testing codes, Procedures,
Equipment and work pieces.

INSPECTION METHOD: LEAK TESTING **LEVEL: 1**
SUBJECT: 6. SAFETY ASPECTS

CONTENTS:

6.1 Control of hazards from toxic and radioactive liquids, vapours and particles and of flammable liquids and vapours
6.2 Safety precautions with compressed gas cylinders
6.3 Safety precautions in pressure and vacuum leak testing
6.4 Preparation of pressurized systems for safe leak testing, rise in temperature dangers
6.5 Industrial safety standards; ASME Boiler & Pressure Vessel Code, ASTM, ASME Pressure Piping Code, others
6.6 Danger in presence of hydrogen
6.7 Sparking and combustion
6.8 Psychological factors and safety program

SPECIFIC OBJECTIVES:

Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Safety standards,
Safety equipment & accessories.

INSPECTION METHOD: LEAK TESTING **LEVEL: 1**
SUBJECT: 7. APPLICATIONS

CONTENTS:

7.1 System reliability through leak testing
7.2 Leak testing to detect material flaws
7.3 Desired degree of leak tightness
7.4 Application of helium leak detection
7.5 Application of halogen leak detection
7.6 Application of bubble leak detection
7.7 Application of vacuum box leak detection
7.8 Application of further and advanced techniques; radioactive tracers, liquid penetrants and chemical tracers, ultrasonic leak testing, acoustic emission leak testing, thermal conductivity and others

---

SPECIFIC OBJECTIVES:

Given the instructor's explanations, the student will be able to understand different applications of leak testing techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board,
Course notes,
Samples.

INSPECTION METHOD: LEAK TESTING **LEVEL: 1**
SUBJECT: 8. DOCUMENTATION OF THE TEST

CONTENTS:

8.1 Registration of operative conditions on test forms and presentation of data sheets
8.2 Listing of anomalies observed during preparation and execution of test

---

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations, the student will be able to fill out test forms and data sheets relating to the test.
8.2 Given the instructor's explanations, the student will be able to list any anomalies observed during testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and development from student experience.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Films,
Course notes and Samples.

INSPECTION METHOD: LEAK TESTING LEVEL: 2
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENT: SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: LEAK TESTING LEVEL: 2
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Type of gases, general equation of gases, perfect gases law (formula and application) pressurization of gases, effects of temperature, atmospheric pressure and vapor pressure

2.2 Basic knowledge of leaks and leakages

d) 2.2.1 Basic knowledge of leaks and leakage through a confining wall, mechanism of outgassing, real leaks and virtual leaks, pressure time relationship, different types of fluid flow in the leakage

2.2.2 Leak conductance, sensitivity of detector and sensitivity of test, calculation of leakages, calculation of conduction from nomograms and conductance in series and in parallel

2.2.2 Definitions and units of pressure, volume and flow rate in leak testing, relationship between the main measurement units, measurement of vapor pressure

2.3 Tracer fluids, liquid and gaseous tracers, physical principles for the detection of different types of tracers, ionization of gases and mass spectrometry, ionization radiations

---

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:

a) know and apply the general equation of gases;
b) understand the effects of temperature, atmospheric and vapour pressure in the pressurization of gases.

2.2 Given the instructor's explanations, the student will be able to:

a) describe the different types of leaks and the conditions of fluid flow through, them;
b) understand the principle of leakage calculations;
c) establish relationships between sensitivity of detectors and sensitivity of test;
d) use the various units related to leak testing.

2.3 Given the instructor's explanations, the student will be able to describe the use different tracers in leak testing and explain the principles for their detection.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and development from student experience

---

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board, Course notes and Films.

INSPECTION METHOD: LEAK TESTING **LEVEL: 2**
SUBJECT: 3. TEST TECHNIQUES

CONTENTS:

3.1 Characteristic of test methods

3.1.1 Locations of leaks; pressurized systems and evacuated systems, tracers inherent to the system and incorporated tracers, detector inherent to the system and detector applied to the system, dynamic and static tests

3.1.2 Leakage measurements; multiple closed systems: in vacuum with tracer gas, closed with air, simple, closed or open units, leakage to vacuum or to atmospheric pressure, dynamic and static tests

---

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:

a) Recognize the different systems in which leak testing could be applied,
b) Understand the techniques used in leak measurements for different systems.
c)

METHODOLOGICAL STRATEGIES:

Instruction's presentation including lecture, demonstration, guided discussion and development from student experience.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes
Films,
Equipment for bubble, pressure change, helium and halogen tests

INSPECTION METHOD: LEAK TESTING **LEVEL: 2**
SUBJECT: 3. TEST TECHNIQUES

CONTENTS:

3.2 Different techniques for the application of leak tests

3.2.1 Bubble test; establishing operative conditions for bubble and foam testing, liquids for bubbles and solutions for foam, examination of seam pipes and welded vessels, check of locks and gates, advantages and limitations

3.2.2 Testing by means of pressure; establishing operative conditions for the test of absolute pressure, relative terminology, pressurization of gases, effect of changes in temperature, vapour pressure and atmospheric pressure, measurement of leakage in vessel and gates, establishing operative conditions for testing with a reference system, applications in the examination of vessels, equation for the determination of leak percentages, positioning of sensors, equations for the determination of leak percentages, positioning of sensors for temperature and dew point, filling in data sheets, advantages and limitations

3.2.3 Test by detection of halogens; operating conditions of the halogen diode detector, operating principles, relative terminology, halogen vapour, operation and maintenance of halogen detectors, set- up and calibrations, application of standards leaks, cleaning and replacement of detectors of gaseous tracers, halogen percentage in r-12 fluid, influence of the halogen background, different ways of applying the technique, contamination measurement, sensitivity of the test, advantages and limitations

---

SPECIFIC OBJECTIVES:

3.2 Given the instructor's explanations, the student will be able to:

a) establish operative conditions for bubble and foam testing and specify liquids and solutions for the test;
b) establish the operative conditions for pressure testing with different techniques in different components and under different conditions;
c) to know the operational principles of halogen diode detectors and establish test conditions;
d) to understand the use, maintenance and calibration of the halogen diode detector;
e) to know the characteristics of different tracers used with the halogen diode detector and the conditions for the application.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, guided discussion and development from student experience.

EQUIPMENT AND RESOURCES:

Writing board Power Point/Transparencies, Slides/Videos, course notes, films, Equipment for bubble, pressure change and halogen testing.

CONTENTS:

3.2.4 Helium leak testing

a) Test with helium spectrometer, functioning principle and operating conditions for the leak test with helium spectrometer, relative terminology, pressure and vacuum technology, operation and maintenance of helium mass spectrometers, calibrations in accordance with different test techniques, sensitivity of the test

b) Percentage of helium in tracers, operation of sniffer, speed, diameter and length of hose. techniques of accumulation in bags, dynamic method with use of probes and bags, static method, pressure system, percentage of helium in the tracer, calculation of leakage rate, advantages and limitations

3.2.5 Advanced techniques

a) Radioactive tracers, applicability, sensitivity and principle of test, krypton-85 gas, advantages and limitations

b) Liquid penetrants and chemical tracers, applicability, sensitivity and characteristics of techniques, penetrant materials, ammonia gas leak test, carbon dioxide tracer gas, chemical fumes leak detector, indicator solutions, advantages and limitations

c) Ultrasonic leak testing, principles, sensitivity, characteristics and applicability of the test, advantages and limitations

d) Acoustic emission leak testing, fundamental principles of acoustic emission leak testing. applicability, sensitivity and characteristics of test, methods of acoustic emission testing, advantages and limitations

e) Vacuum box leak testing techniques, applicability, sensitivity and principle of test, advantages and limitations.

f) Halide torch testing, principles, sensitivity and characteristics of technique, applicability of technique, advantages and limitations

3.2.5 (continued) Advanced techniques

a) High voltage discharge testing, principles of the test, white spark technique, colour differentiation technique, analysis and interpretation, applicability of the test, advantages and limitations

b) Light absorption testing, applicability and characteristics, principles and methods of operation, advantages and limitations

c) Thermal conductivity leak testing, applicability and characteristics, principles and methods of leak testing, advantages and limitations

d) Gas analysis, (gas chromatography, residual gas analysis), fundamental principles of the test, advantages and limitations

3.3 Relative sensitivity and scope of application of the different techniques

3.4 Leak testing in accordance with written procedures for any of the techniques described

---

SPECIFIC OBJECTIVES:

3.2.4 Given the instructor's explanations, the student will be able:

a) to understand the principle of operation of helium mass spectrometer;

b) to know the different techniques for the use of helium mass spectrometer;

c) to know the use, maintenance and calibration of the helium mass spectrometer.

d) to know the conditions for the use of helium in leak testing with the helium mass spectrometer.

3.2.5 Given the instructor's explanations, the student will be able to know the principle of operation and field of application of other techniques: radioactive tracers, liquid penetrants, chemical reagents, ultrasonic leak testing, acoustic emission, vacuum box and halide torch testing, and to describe the relative sensitivity and field of application of the different techniques.

3.2.5 Given the instructor's explanations, the student will be able to know the principle of operation and field of application of techniques such as high voltage discharge, light absorption, thermal conductivity and gas analysis testing.

3.3 Given the instructor's explanations, the student will be able to describe the relative sensitivity and field of application of the different techniques.

3.4 Given the instructor's explanations, the student will be able to apply testing in accordance with written instructions.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstrations, and discussion arising from student experience.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, films,
Equipment for leak testing using helium spectrometer,
Radioactive tracers,
Dye penetrants and chemical agents, ultrasonic leak, acoustic emission,
Vacuum box and halide torch testing techniques.
Equipment for leak testing using high voltage discharge, light absorption, thermal conductivity and gas analysis testing technique.

INSPECTION METHOD: LEAK TESTING **LEVEL: 2**
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.1 Instruments for the measurement of pressure, temperature and dew point, precision of instruments and calibration

4.2 Halogen diode detector, leak control units, gun detector, electron capture, standardization leaks

4.3 Helium mass spectrometer, vacuum unit, control panel, spectrometer, sniffers

4.4 Accessories, vacuum pumps, vacuum valves, vacuum pipes, connectors for vacuum, cold traps, sealing compound for vacuum, calibrated leaks

4.4.1 Gauges, classification and selection of vacuum gauges, assembly criteria and pressure reading techniques of all gauges, mechanical gauges (bourdon gauges and diaphragm gauges), u-tube manometers, McLeod gauges, Pirani gauges, thermocouple gauges, hot cathode ionisation gauges, cold cathode ionisation gauges

4.4.2 Pumps, classification and selection of vacuum pumps, knowledge of maintenance and assembly criteria of pumps, working principle and estimation of pump size, rotary vane and rotary piston pumps, roots pumps, oil diffusion pumps, liquid nitrogen traps

---

SPECIFIC OBJECTIVES:

---

4. Given the instructor's explanations, and demonstrations, the student will be able to set up and control the equipment and accessories for the different techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, demonstrations, guided discussion and development of supervised practical experiments.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes, Films,
Equipment for different leak tests and accessories.

INSPECTION METHOD: LEAK TESTING LEVEL: 2
SUBJECT: 5. CODES, STANDARDS, PROCEDURES AND GUIDELINES

CONTENTS:

5.1 Standards applicable to leak testing
- 5.1.1 Test methods
- 5.1.2 Materials for the test (ASTM, API, DIN, MIL, IRAM)
- 5.1.3 ASME code

5.2 Test specifications and procedures
- 5.2.1 Definition of testing and instructions, considering field of application, equipment and technique.
- 5.2.2 Interpretation and evaluation
- 5.2.3 Formulation of instructions for the test
- 5.2.4 Contents of codes, standards, specification and guidelines

5.3 National standards for leak testing and testing personnel
- 5.3.1 Quality control of the test and procedure for its administration
- 5.3.2 Quality assurance requirements

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to:
- a) establish classification systems for the application of leak testing according to the standards in force;
- b) explain the criteria for application of leak testing according to the standards in force.

5.2 Given the instructor's explanations and the performance of the practical exercises, the student will be able to:
- a) interpret general and specific test procedures for the leak test with liquid penetrants;
- b) develop test instructions for level1;
- c) formulate the information required for documenting the test and presenting reports.

5.3 Given the instructor's explanations and the performance of the practical exercises. the student will be able to recognize the qualification and certification standard for NDT personnel established in the respective country.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, demonstration, supervised practice and guided discussion.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Samples of standards and codes, and Comparative tables.

INSPECTION METHOD: LEAK TESTING **LEVEL: 2**
SUBJECT: 6. SAFETY ASPECTS

CONTENTS:

6.1 Problems of industrial safety in the use of chemical and inflammable products
  6.1.1 Applicable safety standards
  6.1.2 Drafting of safety instructions for the personnel involved
  6.1.3 Safety factors applicable to the test
6.2 Control of hazards from toxic and radioactive liquids, vapours and particles and of flammable liquid and vapours.
6.3 Safety precautions with compressed gas cylinders.
6.4 Safety precautions in pressure and vacuum leak testing.
6.5 Preparation of pressurized systems for safe leak testing. Rise in temperature dangers.
6.6 Industrial safety standards: ASME Boiler and Pressure Vessel Code, ASTM, ASME Pressure Piping Code, others.
6.7 Danger in presence of hydrogen.
6.8 Sparking and combustion.
6.9 Psychological factors and safety program.

SPECIFIC OBJECTIVES:

Given the instructor's explanations and discussion of the subjects, the student will be able to:

a) describe the risks inherent in the use of chemical and inflammable products;
b) list the applicable safety standards;
c) prepare safety instructions for application of the test.
d)

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, guided discussions, demonstrations and supervised practice.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes, Safety standards,
Safety equipment and accessories.

INSPECTION METHOD: LEAK TESTING **LEVEL: 2**
SUBJECT: 7. APPLICATIONS

CONTENTS:

7.1 System reliability through leak testing
7.2 Leak testing to detect material flaws
7.3 Desired degree of leak tightness
7.4 Application of helium leak detection
7.5 Application of halogen leak detection
7.6 Application of bubble leak detection
7.7 Application of vacuum box leak detection
7.8 Application of further and advanced techniques, radioactive tracers, liquid penetrants and chemical tracers, ultrasonic leak testing, acoustic emission leak testing, thermal conductivity and others

---

SPECIFIC OBJECTIVES:

Given the instructor's explanations, the student will be able to understand different applications of leak testing techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Course notes, Samples.

INSPECTION METHOD: LEAK TESTING **LEVEL: 2**
SUBJECT: 8. DOCUMENTATION OF THE TEST

CONTENTS:

8.1 Interpretation of test procedures and preparation of written instructions for level 1 operators, preparation of data sheets, preparation of reports

---

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations, the student will be able to:

a) interpret test procedures and prepare written instructions for level 1 operators;
b) prepare data sheets and reports of the test.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, demonstrations, and guided discussions arising from student experience.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes, Films,
Samples.

INSPECTION METHOD: LEAK TESTING LEVEL: 3
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE FOR LEVEL 3

INSPECTION METHOD: LEAK TESTING LEVEL: 3
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Type of gases, general equation of gases, perfect gases law, difference between perfect and real gases, pressurization of gases, effects of temperature, atmospheric pressure and vapor pressure, reduction of pressure and data corrections, analysis of temperature and dew point data, relationship between mean free path and pressure

2.2 Basic knowledge of leaks and leakages

2.2.1 Basic knowledge of leaks and leakage, real and virtual leaks, influence of virtual leaks in a pressure rise test, general theory of viscous fluids, Bernoulli's equations, behavior of different gases and vapours from the point of view of outgassing

2.2.2 Leak conductance, sensitivity of detector and sensitivity of test, calculation for producing vacuum in confined system according to pump and aspiration line capacities, influence of different flow conditions

2.2.3 Definition and units of pressure, volume and flow rate, used in leak testing, expression of leakage in power units, calculation and conversions

2.3 Liquid and gaseous tracers, physical principles for the detection of different types of tracers, ionization of gases and mass spectrometry, ionizing radiation

---

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:

a) make calculation using the general equation of gases;
b) define pressure from the point of view of kinetic theory of gases;
c) calculate standard atmospheric pressure.

2.2 Given the instructor's explanations, the student will be able to:

a) define relationship between mean path, diameter of conduit and type of flow;
b) recognize influence of virtual leaks in pressure test;
c) define different conditions of viscous flow through a leak;
d) define leak conductance;
e) know the influence of conductance on different flow conditions;
f) make calculations of leakage for the different techniques;
g) make calculations for producing vacuum in confined systems;
h) make calculations of sensitivity of the test according to the detector sensitivity and applied technique
i) Use properly the different units employed for leak testing calculations.

2.3 Given the instructor's explanations, the student will be able to:

a) explain the physical principles for detection of the different types of tracers;
b) select suitable tracer fluids for each leak testing method.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, and course notes.

CONTENTS:

3.1 Location of leak and measurement of leakage, bubble test, pressure measurement, detection of halogens, detection of helium, radioactive tracers, liquid penetrants, selection of techniques and applicable criteria, relative sensitivity between the different techniques

3.2 Location of leaks, pressurized systems and evacuated systems, inherent tracers and incorporated tracers, detector included in the system and detector applied to system, dynamic and static tests, analysis and selection of different ways of operation, measurement of leakage, multiple closed systems: in vacuum, closed with tracer gas, closed with air, simple closed or open units, leakage to vacuum of atmospheric pressure, dynamic and static tests, analysis and selection of different modes of operation

3.3 Different techniques for the application of leak testing:

3.3.1 Bubble test, determination of conditions for application of bubble test, bubble and foam formation tests, liquids for producing bubbles and solutions for foaming, design of test for seamed pipes and welded vessels, verification of locks and gates, applications in pneumatic tests, sensitivity evaluation, measurement of leakage with bubble technique

3.3.2 Testing by pressure measurement, conditions for absolute pressure test, relative terminology, pressurization of gases, effects of changes in temperature, pressure, steam and atmospheric pressure, equations for the determination of pressure changes, measurement of leakage rate in vessels and gates, conditions for testing with systems, vessel examination, pressure differentials, equations for the determination of leakage percentages, positioning of temperature and dew point sensing devices to ensure the reliability of test, analysis of temperature and dew point data, analysis and evaluation of results

3.3.3 Halogen detection tests, operating principles of halogen diode detector, establishment of test conditions, operation and maintenance of halogen detectors, set-up and calibration, application of normalized leaks, cleaning and replacement of detectors, tracer gases, halogen percentage, refrigerating gases, effect of heat on refrigerant r-12, influence of halogen background, different ways of applying technique, sensitivity of test, design operation and filling of standard leaks, analysis and evaluating of sensitivity of test, discussion of results, calculation of leaks for refrigeration systems

3.3.4 Helium spectrometer testing, functioning principle and establishment of operative conditions for leak testing with helium spectrometer, relative terminology, pressure and vacuum technology, vacuum pumps, operation and maintenance of helium mass spectrometers, calibrations in accordance with different test techniques, helium percentage in tracer, operation of sniffer, speed, diameter and length of hose, techniques for accumulation in bags, dynamic method with the use of probes or bags, static method, pressure system, helium percentage in tracer, leakage calculations

3.3.5 Further and advanced techniques

a) Radioactive tracers, applicability and principle of test, krypton-85 gas, advantages and limitations

b) Liquid penetrants and chemical tracers, applicability and characteristics of techniques, penetrant materials, and ammonia gas leak test, carbon dioxide tracer gas

c) Chemical fumes leak detector, indicator solutions, advantages and limitations
d) Ultrasonic leak testing, principles, characteristics and applicability of the test, advantages and limitations
e) Acoustic emission leak testing, fundamental principles of acoustic emission leak testing, applicability and characteristics, methods of acoustic emission testing, advantages and limitations
f) Vacuum box leak testing techniques, applicability and principle of test, advantages and limitations
g) Halide torch testing, principles and characteristics of technique, applicability of the test, advantages and limitations
h) High voltage discharge testing, principles of the test, white sparks technique, colour differentiation technique, analysis and interpretation, applicability of the test, advantages and limitations
i) Light absorption testing, applicability and characteristics, principles and methods of operation, advantages and limitations
j) Thermal conductivity leak testing, applicability and characteristics, principles and methods of leak testing, advantages and limitations
k) Gas analysis, (gas chromatography, residual gas analysis), fundamental principles of the test

3.4 Comparative analysis of applicability of different test techniques for compliance with examination specifications

---

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:
a) select the best technique for the location of leaks and measurement of leakage according to type of leak to be detected and the system being tested;
b) establish relative sensitivity between the different methods and techniques.

3.2 Given the instructor's explanations, the student will be able to:
a) analyze the applicability of the different techniques according to the characteristics of the system to be tested;
b) establish conditions for dynamic and static tests.

3.3 Given the instructor's explanations, the student will be able to:
a) determine conditions for the applicability of each method and technique;
b) select most suitable method and technique to be applied;
c) establish the reference system for evaluation of test sensitivity;
d) given the instructor's explanations, the student will be able to make comparative analysis of applicability of the various methods and techniques in accordance with the specifications.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, solution of problems and development of supervised practical experiments.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, equipment for bubble, helium and pressure testing, halogen detection and helium spectrometry, equipment for testing by further and advanced techniques.

INSPECTION METHOD: LEAK TESTING **LEVEL: 3**
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.1 Instruments for the measurement of pressure, temperature and dew point, precision of instruments and calibration
4.2 Halogen diode detector, leak control units, gun detector, standard leaks
4.3 Helium mass spectrometer, vacuum an it, control panel, spectrometer, sniffer
4.4 Accessories, vacuum pumps, vacuum valves, vacuum pipelines, vacuum connectors, cold traps, sealing compound, calibrated leaks
  4.4.1 Gauges, (assembly criteria and pressure reading techniques of all gauges) mechanical gauges (bourdon gauges and diaphragm gauges). u-tube manometers, Mcleod gauges, pirani gauges, thermocouple gauges, hot cathode ionisation gauges, cold cathode ionisation gauges
  4.4.2 Pumps, vane and rotary piston pump, roots pumps, oil diffusion pumps, liquid nitrogen traps
4.5 Selection of equipment and accessories
  4.5.1 Set-up and verification of equipment and accessories
  4.5.2 Design of reception tests, control and verification tests for equipment and accessories, calibration and comparison of instruments for the measurement of pressure

---

SPECIFIC OBJECTIVES:

---

4. Given the instructor's explanations, the student will be able to:
  a) demonstrate knowledge of the constructive characteristics and operational parameters of the various equipment and accessories applicable to the different testing methods and techniques;
  b) demonstrate knowledge of the setting- up and verification requirements of the various tests equipment and accessories;
  c) demonstrate capability for the design of reception, control and verification tests for equipment and accessories;
  d) demonstrate capability to establish calibration procedures for the instruments and equipment used.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, solution of problems and practical student involvement.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Diverse equipment for leak detection.

INSPECTION METHOD: LEAK TESTING LEVEL: 3
SUBJECT: 5. CODES, STANDARDS, PROCEDURES, SPECIFICATIONS AND GUIDELINES

CONTENTS:

5.1 Examination specifications
- 5.1.1 Function of design engineering
- 5.1.2 Design and building codes
- 5.1.3 ASME Boiler and Pressure Vessel Code

5.2 Standards specific to leak testing
- 5.2.1 National and international standards (IRAM, API, ASTM, DIN, MIL)
- 5.2.2 Criteria for selection and interpretation of specifications, codes, standards and guidelines

5.3 Testing procedures
- 5.3.1 Establishment of test methods for new testing problems
- 5.3.2 Selection of possible additional testing methods
- 5.3.3 Formulation of test procedures
- 5.3.4 General and specific procedures

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to interpret, analyze and apply specifications for examination prepared by design engineering or called for in codes of practice;

5.2 Given the instructor's explanations, the student will be able to analyze, evaluate and apply leak testing according to national and international standards;

5.3 Given the instructor's explanations, the student will be able to develop, evaluate and apply written procedures for leak testing, conforming to externally imposed requirements and those imposed by the specimen, equipment available and work environment.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and supervised practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Samples codes,
Standards, specifications and procedures.

INSPECTION METHOD: LEAK TESTING **LEVEL: 3**
SUBJECT: 6. SAFETY ASPECTS

CONTENTS:

6.1 Problems of industrial safety in the use of chemical and inflammable products
  6.1.1 Applicable safety standards
  6.1.2 Drafting of safety instructions for the personnel involved
  6.1.3 Safety factors applicable to the test
6.2 Control of hazards from toxic and radioactive liquids, vapours and particles and of flammable liquid and vapours
6.3 Safety precautions with compressed gas cylinders
6.4 Safety precautions in pressure and vacuum leak testing
6.5 Preparation of pressurized systems for safe leak testing, rise in temperature dangers
6.6 Industrial safety standards, ASME Boiler and Pressure Vessel Code, ASTM, ASME Pressure Piping Code, others
6.7 Danger in presence of hydrogen
6.8 Sparking and combustion
6.9 Psychological factors and safety programme

SPECIFIC OBJECTIVES:

Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out and apply good safety practices in the application of leak testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Safety standards
Safety equipment and accessories

INSPECTION METHOD: LEAK TESTING **LEVEL: 3**
SUBJECT: 7. APPLICATIONS

CONTENTS:

7.1 System reliability through leak testing
7.2 Leak testing to detect material flaws
7.3 Desired degree of leak tightness
7.4 Application of helium leak detection
7.5 Application of halogen leak detection
7.6 Application of bubble leak detection
7.7 Application of vacuum box leak detection
7.8 Application of further and advanced techniques, radioactive tracers, liquid penetrants and chemical tracers, ultrasonic leak testing, acoustic emission leak testing, thermal conductivity and others

---

SPECIFIC OBJECTIVES:

Given the instructor's explanations, the student will be able to understand different applications of leak testing techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Samples.

INSPECTION METHOD: LEAK TESTING **LEVEL: 3**
SUBJECT: 8. DOCUMENTATION OF THE TEST

CONTENTS:

8.1 Test procedures in accordance with specifications and standards
8.2 Test and data sheets, inspection protocols.

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations, the student will be able to prepare test procedures in accordance with specifications and standards.
8.2 Given the instructor's explanations, the student will be able to prepare test forms, data sheets and write inspection protocols.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Standards and codes
Specifications and procedures.

10. VIII. INSPECTION METHOD: VISUAL TESTING

SUBJECT	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	3	5	[1)]
2. PHYSICAL PRINCIPLES OF THE TEST	2	2	1
3. VISION	1	1	2
4. EQUIPMENT AND ACCESSORIES	4	8	4
5. WORK PARAMETERS AND CONDITIONS	2	2	4
6. IMAGE RECORDING	1	2	6
7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	1	3	4
8. SAFETY	-	-	1
9. APPLICATIONS	2	1	2
TOTAL	16	24	24[1)]

[1)] In addition to the above 24 hours a general knowledge common core course for level 3 (applicable to all NDT methods) is recommended, which shall be successfully completed only once.

INSPECTION METHOD: VISUAL TESTING LEVEL: 1
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: VISUAL TESTING LEVEL: 1
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Fundamentals of visual and optical testing
- 2.1.1 Description of visual and optical testing
- 2.1.2 Nature of light
  - a) Wave theory
  - b) Quantum theory
- 2.1.3 Measurement of properties of light

2.2 Sources of light
- 2.2.1 Electromagnetic radiation, light spectra
- 2.2.2 Characteristics of light, intensity and color
- 2.2.3 Measurement of properties of light
- 2.2.4 Illumination and luminance
- 2.2.5 Experimental laws of photometry
- 2.2.6 Units

2.3 Phenomena of regular and diffuse reflection, refraction, dispersion, diffraction, absorption and transmission of light

2.4 Emissivity and reflectance

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:
- a) list properties of light;
- b) List other electromagnetic radiation;
- c) differentiate between intensity and colour.

2.2 Given the instructor's explanations, the student will be able to:
- a) describe source of light;
- b) differentiate between illumination and luminance;
- c) establish variation of light intensity with distance.

2.3 Given the instructor's explanations, the student will be able to enumerate different phenomena occurring during transmission of light through different media.

2.4 Given the instructor's explanations, the student will be able to differentiate between emissivity and reflectance.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Slides, Power Point/Transparencies, Slides/Videos, writing board, course notes, various equipment for light emission.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 1**
SUBJECT: 3. VISION

CONTENTS:

---

3. Physiological factors, eyes, components, visual functions
3.1 Human eye
  3.1.1 Physical description and formation of image
  3.1.2 Perception of intensity and color
    3.1.3 Visual acuity
3.2 Reaction of the eye to light excitation
  3.2.1 Sensitivity and adaptation to variations
    3.2.2 Perception of contrast and color
3.3 Vision defects
  3.3.1 Symptomatic disturbances of vision
    a) Partial loss of vision
    b) Complete loss of vision

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:
  a) identify the main components of the human eye;
  b) differentiate between intensity and color perception;
  c) define visual acuity.
3.2 Given the instructor's explanations, the student will be able to:
  a) recognize threshold limits for intensity and color perception;
  b) enumerate vision defects.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures and guided discussions.

EQUIPMENT AND RESOURCES:

Slides, Power Point/Transparencies, Slides/Videos, Writing board and Course notes.

INSPECTION METHOD: VISUAL TESTING LEVEL: 1
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.1 Instruments for illumination
- 4.1.1 Different types of light sources; efficiency and useful life
- 4.1.2 Auxiliary equipment for light sources: tripod supports, transformers, filters, collimators, etc
- 4.1.3 Sources of non-visible radiation; ultraviolet, infrared lamps, filters

4.2 Visual aids
- 4.2.1 Lenses, prisms and mirrors, characteristics of construction
- 4.2.2 Optical systems; microscopes, telescopes, projectors, characteristics of construction, optical holographic methods, automated visual inspection and magnifier
- 4.2.3 Micro-alignment telescope and accessories
- 4.2.4 Gauges and measuring devices

4.3 Image transmitting instruments
- 4.3.1 Instruments for optical transmission of images; rigid and flexible endoscopes, characteristics of construction
- 4.3.2 Combination equipment for the transmission of images; optical equipment coupled to TV systems [C.C.T.V.]
- 4.3.3 Digital camera

4.4 Equipment for monitoring
- 4.4.1 Optical vibration monitoring equipment

4.5 In-situ metallography

SPECIFIC OBJECTIVES:

---

4. 1 Given the instructor's explanations, the student will be able to:
- a) list different types of light sources and give reference to efficiency and useful life;
- b) list ancillary equipment normally used with light sources;
- c) describe ultraviolet lamps.

4.2 Given the instructor's explanations, the student will be able to:
- a) describe lenses, prisms and mirrors;
- b) describe different optical systems employed in T.V.

4.3 Given the instructor's explanations, the student will be able to:
- a) describe construction and operation of rigid endoscopes;
- b) describe construction and operation of flexible endoscopes;
- c) describe the use of different vision angles in endoscopes;
- d) describe T.V. systems.

4.4 Given the instructor's explanations, the student will be able to explain different types of monitoring equipment.

4.5 Given the instructor's explanations, the student will be able to explain the process of in-situ melallography.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including demonstration and student practical work.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes,
Light sources,
Visual aids,
Instruments mentioned above.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 1**
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

5.1 Surface preparation for the examination
5.2 Observation techniques
  5.2.1 Direct visual examination
  5.2.2 Remote visual examination
  5.2.3 Translucent visual examination
5.3 Illumination conditions dependent on type of surface to be examined and expected defects
5.4 Evaluation of visual acuity, use of Jaeger chart, qualification of the examination using reference samples
5.5 Inspection characteristics and scope of tests
  5.5.1 General VT; checking general condition, first impression of test piece e.g. identification, set up.
  5.5.2 Specific VT; testing for specific characteristics requiring higher level of illumination and equipment, e.g. deviation in shape, surface texture, defects
5.6 Data recording

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to describe the surface preparation for visual examination.
5.2 Given the instructor's explanations, the student will be able to list the different techniques applied in visual examination.
5.3 Given the instructor's explanations, the student will be able to describe different illumination conditions depending on the surface to be examined.
5.4 Given the instructor's explanations, the student will be able to describe the use of the Jaeger chart and reference samples.
5.5 Given the instructor's explanations, the student will be able to produce a record of data concerning a special visual test.
5.6 Given the instructor's explanations, the student will be able to operate test equipment using techniques following test instructions.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, demonstrations and student practice.

EQUIPMENT AND RESOURCES:

Slides, Power Point/Transparencies, Slides/Videos, writing board, course notes,
Jaeger charts, and sample pieces.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 1**
SUBJECT: 6. IMAGE RECORDING

CONTENTS:

6.1 Photographic recording
  6.1.1 Main characteristics and fundamentals of photographic cameras
  6.1.2 Different types of films
6.2 Replication; conditioning techniques for observation and special requirements for surface preparation
6.3 Film digitization and image processing

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanations, the student will be able to:
  a) describe the main characteristics of photographic cameras;
  b) describe the common films used in visual inspection.
6.2 Given the instructor's explanations, the student will be able to describe the different techniques used to produce a replica and the special requirements for surface preparation.
6.3 Given the instructor's explanations, the student will be able to describe film digitization and image processing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including demonstrations and student practice with different photographic cameras and films.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Writing board
Course notes,
Replica samples,
Photographic cameras and Photographic films.

INSPECTION METHOD: VISUAL TESTING LEVEL: 1
SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

7.1 General knowledge
- 7.1.1 National, regional and international codes and standards
- 7.1.2 General knowledge of specifications

7.2 Instructions for the test
- 7.2.1 Interpretation

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanations and various classifications of visual examination processes in accordance with standards, the student will be able to prepare a table classifying the techniques in accordance with various standards, explaining the relationship between them.

7.2 Given the instructor's explanations and written instructions, the student will be able to:
a) interpret the instructions and perform the test correctly;
b) fill out the test forms and note the results.

METHODOLOGICAL STRATEGIES:

Instructor' s presentation including lectures, demonstrations and guided discussions.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, and Slides/Videos
Codes,
Standards and specifications,
Test samples,
Course notes.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 1**
SUBJECT: 8. SAFETY ASPECTS

CONTENTS:

8.1 Safety and environmental consideration
  8.1.1 Safety for visual and optical tests
    a) Need for safety
    b) Laser hazards
    c) Infrared hazards
    d) Ultraviolet hazards
    e) Photosensitizers
    f) Damage to the retina
    g) Thermal factor
    h) Blue hazards
    i) Eye protection filters
8.2 Industrial safety standards
8.3 Visual and optical testing environment
    a) Cleanliness
    b) Texture and reflectance
    c) Lighting for V.T.
    d) Light intensities
    e) Vision in the testing environment
8.4 Visual safety environment

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out.
8.2 Given the instructor's explanations, the student will be able to apply good safety practices in the application of visual testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Safety standards,
Safety equipment & accessories.

INSPECTION METHOD: VISUAL TESTING LEVEL: 1
SUBJECT: 9. APPLICATIONS

CONTENTS:

9.1 Applications: VT during manufacturing process
- 9.1.1 Applications of visual and optical tests in the electric power industries
  Joining processes, acceptance standards, recording and reporting visual test results
- 9.1.2 Specific visual inspection applications
  Pumps, values, bolting, forging, rolled stock and casting.
- 9.1.3 Applications of visual and optical tests in the transportation industries
  Optical tests in the automobile industries, optically aided visual testing of aircraft structure.

9.2 Interface of visual testing with other NDT methods
Visual testing of liquid penetrant, leak testing, radiographic testing, magnetic particle testing, ultrasonic testing & etc.

9.3 Applications of photography in visual testing
Photographs as a permanent record for VT, photogrammetry for documenting the condition of petrochemical furnaces conclusions.

9.4 Visual testing of ceramics

9.5 Visual testing of threads in oil country tubular goods

9.6 Visual testing of composite materials

9.7 Visual testing of micro-electronic components

9.8 In-service Inspection
- 9.8.1 ISI of plants in the light of call up maintenance card
- 9.8.2 Displacement measurement of moving parts of equipments i.e. pumps compressor, motor & etc.
- 9.8.3 Optical techniques for vibration monitoring
  a) Static measurement
  b) Dynamic measurement

SPECIFIC OBJECTIVES:

Given the instructor's explanations, the student will be able to understand different applications of different visual testing techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, and course notes.

INSPECTION METHOD: VISUAL TESTING LEVEL: 2
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE for GENERAL KNOWLEDGE

INSPECTION METHOD: VISUAL TESTING LEVEL: 2
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Fundamentals of visual and optical testing
- 2.1.1 Description of visual and optical test
- 2.1.2 Luminous energy test, geometrical optics, image formation, light sources, stroboscopic sources, light detection and recording, fluorescence detection

2.2 Nature of light
- a) Wave theory
- b) Quantum theory
- 2.2.1 Electromagnetic radiations; light spectra, infrared and ultraviolet radiation
- 2.2.2 Characteristics of light; intensity and colour
- 2.2.3 Magnitudes and units
- 2.2.4 Measurement

2.3 Basic laws of the phenomena of regular and diffuse reflection, refraction, dispersion, diffraction, absorption, and transmission of light

2.4 Emissivity and reflectance

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:
- a) list the properties of light;
- b) establish the characteristics of the electromagnetic spectrum;
- c) establish the limits of the visible spectrum.

2.2 Given the instructor's explanations, the student will be able to:
- a) define the sources of equal intensity;
- b) define luminous flux;
- c) establish the variations of the light with the distance;
- d) define different units of illumination.

2.3 Given the instructor's explanations, the student will be able to:
- a) define laws of reflection and refraction;
- b) understand the concept of dispersion, diffraction, absorption, transmission of light

2.4 Given the instructor's explanations, the student will be able to establish the relation between emissivity and reflectance.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, guided discussions and review of examples including simple calculations.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, course notes, and writing board.

INSPECTION METHOD: VISUAL TESTING LEVEL: 2

SUBJECT: 3. VISION

CONTENTS:

---

3 Vision
3.1 Human eye, the anatomical and physical aspects of the eye
- 3.1.1 Formation of the image
- 3.1.2 Perception of intensity and colour
- 3.1.3 Separation ability
- 3.1.4 Visual acuity

3.2 Reaction of the eye to excitation
- 3.2.1 Adaptation, reaction to glare
- 3.2.2 Distance and relief perception (stereoscopic perception)
- 3.2.3 Perception of contrast and colour
- 3.2.4 Threshold levels of intensity

3.3 Vision defects
- 3.3.1 Types of blindness; night blindness; day blindness; colour blindness
- 3.3.2 Symptomatic disturbance
  - a) Partial loss of vision
  - b) Complete loss of vision
- 3.3.3 Injuries
  - a) Thermal injuries
  - b) Electrical injuries
  - c) Radiation injuries

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:
- a) identify the main components of the human eye;
- b) explain image formation;
- c) separation ability;
- d) define visual acuity;
- e) explain how the eye perceives the difference between intensity and color;

3.2 Given the instructor's explanations, the student will be able to:
- a) develop the concepts of illumination and luminance;
- b) explain the concept of stereoscopic vision;
- c) list and explain visual defects;
- d) understand the levels of intensity and color.
- e)

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, development from student experience and guided discussion of examples with practical student involvement.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos; course notes; and Writing board.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 2**
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.1 Instruments for illumination
- 4.1.1 Source of visible radiation, spectral quality, efficiency and useful life
- 4.1.2 Classification of the sources
  - a) Continuous
  - b) Flash
  - c) Incandescent
  - d) Discharge
  - e) Fluorescent
  - f) Electronic flash
- 4.1.3 Ancillary equipment for light sources
  - a) Tripod supports
  - b) Transformers
  - c) Filters
  - d) Collimators, etc.
- 4.1.4 Types of illumination; directional; diffused; secondary
- 4.1.5 Sources of non-visible radiation, ultraviolet, infrared, filters

4.2 Machine vision technology
- 4.2.1 Lighting techniques, optical filtration, image processing
- 4.2.2 Image segmentation
- 4.2.3 Temperature indicating material
- 4.2.4 Chemical aids

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to:
- a) know the sources in terms of the spectral quality of the radiation;
- b) know the efficiency and useful life of the sources;
- c) classify different types of sources;
- d) identify sources based on the construction characteristics;
- e) recognize the use of various accessories for illumination systems;
- f) ensure control requirements for result repeatability.

4.2 Given the instructor's explanations, the student will be able to describe the use of machine vision technology and associated aids

---

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical use of equipment, development from student experience and guided discussion of examples.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, sample pieces, auxiliary equipment, course notes, writing board, light sources, light transmitting equipment, and visual aids.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 2**
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.3 Visual aids
- 4.3.1 Lenses, prisms, mirrors, characteristics of construction
- 4.3.2 Microalignment telescope, principle and accessories
- 4.3.3 Optical systems, microscopes, telescopes, projectors, characteristics of construction, Image transmitting instruments, optical holographic methods, automated visual inspection
- 4.3.4 Gauges and measuring devices

4.4 Image transmitting instruments
- 4.4.1 Instruments for optical transmission of images, rigid and flexible endoscope, periscope, basic principles and operations of image transmitting instruments and their construction characteristics.
- 4.4.2 Combination equipment for the transmission of images: optical equipment coupled to T.V. systems. Basic principles and operation, construction characteristics, scope and limitations; Digital cameras

4.5 Optical equipment for monitoring vibration

4.6 In-situ metallography

SPECIFIC OBJECTIVES:

4.3 Given the instructor's explanations, the student will be able to:
a) list the main optic laws;
b) apply those laws with simple calculations;
c) define lenses, prisms, mirrors, characteristics;
d) recognize different optical systems and describe their method of operation;
e) recognize the range of application and limitations of the equipment.

4.4 Given the instructor's explanations, the student will be able to:
a) recognize and describe image transmitting equipment;
b) operate and understand the operation characteristics;
c) select equipment suitable to requirements;
d) use schemes to explain combination systems of image transmission;
e) know the applications of T.V. systems.

4.5 Given the instructor's explanations, the student will be able to operate basic optical vibration monitoring equipment

4.6 Given the instructor's explanations, the student will be able to take surface replicas for in-situ metallography

---

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical use of equipment, development from student experience and guided discussions.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, light transmitting equipment, course notes, light sources, ancillary equipment, visual aids, sample pieces, and Writing board.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 2**
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

5.1 Surface preparation for examination
5.2 Observation techniques
  5.2.1 Direct visual examination
  5.2.2 Remote visual examination
5.3 Illumination conditions dependent on type of surface to be examined and expected defects
5.4 Evaluation of visual acuity, use of Jaeger chart and reference samples
5.5 Presentation of results to be used in analysis, documentation and filing
5.6 Visual and optical testing procedures

SPECIFIC OBJECTIVES:

5.1 Given the instructor's explanations, the student will be able to describe the surface preparation for visual examination.
5.2 Given the instructor's explanations, the student will be able to list the different techniques applied in visual examination.
5.3 Given the instructor's explanations, the student will be able to:
  a) describe different illumination conditions dependent on the surface to be examined;
  b) select appropriate equipment dependent on different conditions and choose a technique suitable for the actual test problem, define its scope, field of application and limitations.
5.4 Given the instructor's explanations, the student will be able to describe the use of the Jaeger chart and reference samples.
5.5 Given the instructor's explanations, the student will be able to:
  a) produce a record of data concerning a specific visual test;
  b) translate the data in a report to analyze, document and file;
  c) write instructions sheet.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical student involvement, development from student experience and guided discussion of examples.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, course notes, writing board, sample pieces, and Jaeger charts.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 2**
SUBJECT: 6. IMAGE RECORDING

CONTENTS:

6.1 Photographic recording
  6.1.1 Main characteristics and fundamentals of photographic cameras
  6.1.2 Different types of film
6.2 Replicas, different techniques, conditioning for observations
6.3 Film digitization and image processing

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanations, the student will be able to:
  a) describe the main characteristics of photographic cameras;
  b) describe the common films used in visual inspection and explain selection criteria.
6.2 Given the instructor's explanations, the student will be able to:
  a) describe the different techniques to produce a replica and special requirements for surface preparation;
  b) list some of the materials used in different types of replicas.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, development from student experience and guided discussion of examples.

EQUIPMENT AND RESOURCES:

Power Point/Transparencies, Slides/Videos, Course notes, Writing board,
Photographic cameras and Photographic films,
Replicas, Replica materials,
Sample pieces.

INSPECTION METHOD: VISUAL TESTING LEVEL: 2
SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

7.1 General knowledge and overview of codes and standards
  7.1.1 General knowledge of specifications and procedures
  7.1.2 Interpretation of procedures and compilation of test instructions
7.2 Performance of test in accordance with written instructions
  7.2.1 Records of operating conditions on test forms
  7.2.2 Evaluation of tasks carried out by level 1 operators
7.3 Instructions for testing in special situations
  7.3.1 Range of application of the test, equipment and technique
  7.3.2 Visual testing acceptance criteria for welds

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanations and testing procedures, the student will be able to:
  a) demonstrate understanding of the significance and application of codes, standards, specifications and procedures;
  b) recognize various standards existing for the application of visual inspection;
  c) prepare instructions for testing, describing all steps to be followed to perform the test.
7.2 Given the instructor's explanations, the student will be able to establish and evaluate tasks for level 1 personnel.
7.3 Given the instructor's explanations, the student will be able to formulate instructions for testing under special conditions and according to requirement of standards adopted for the actual working conditions.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including lecture, guided discussion, practical exercise on interpretation of procedures and compilation of written instructions.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, and Slides/Videos
Codes, Standards (ASME, ASTM, DIN, API, BSI, COVENIN, JIS),
Forms for data registration,
Test procedures and examples of written instructions,
Work pieces,
Equipment and accessories.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 2**
SUBJECT: 8. SAFETY ASPECTS

CONTENTS:

8.1 Safety and environmental consideration
  8.1.1 Safety for visual and optical tests
    a) Need for safety
    b) Laser hazards
    c) Infrared hazards
    d) Ultraviolet hazards
    e) Photosensitizers
    f) Damage to the retina
    g) Thermal factor
    h) Blue hazards
    i) Eye protection filters
8.2 Industrial safety standards
8.3 Visual and optical testing environment
    a) Cleanliness
    b) Texture and reflectance
    c) Lighting for V.T.
    d) Light intensities
    e) Vision in the testing environment
8.4 Visual safety recommendations

SPECIFIC OBJECTIVES:

8.1 Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out.
8.2 Given the instructor's explanations, the student will be able to apply good safety practices in the application of visual testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Safety standards,
Safety equipment & accessories.

INSPECTION METHOD: VISUAL TESTING LEVEL: 2
SUBJECT: 9. APPLICATIONS

CONTENTS:

9.1 Applications: VT during manufacturing process
- 9.1.1 Applications of visual and optical tests in the electric power industries
- 9.1.2 Joining processes, acceptance standards, recording and reporting visual test results
- 9.1.3 Specific visual inspection applications, pumps, values, bolting, forging, rolled stock and casting
- 9.1.4 Applications of visual and optical tests in the transportation industries, optical tests in the automobile industries, optically aided visual testing of aircraft structure

9.2 Interface of visual testing with other NDT methods.; visual testing of liquid penetrant, leak testing, radiographic testing, magnetic particle testing, ultrasonic testing etc.

9.3 Applications of photography in visual testing; photographs as a permanent record, photogrammetry for documenting the condition of petrochemical furnaces

9.4 Visual testing of ceramics

9.5 Visual testing of threads in oil industry tubular goods

9.6 Visual testing of composite materials

9.7 Visual testing of micro electronic components

9.8 Visual and optical testing in metal industry

9.9 In-service inspection
- 9.9.1 ISI of plants in the light of call up maintenance card
- 9.9.2 Displacement measurement of moving parts of the components i.e. pumps, compressors, motors, etc.
- 9.9.3 Optical vibration monitoring
  a) Static measurement
  b) Dynamic measurement

SPECIFIC OBJECTIVES:

Given the instructor’s explanations, the student will be able to understand different applications of different visual testing techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, and Course notes.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 3**
SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS: SEE SEPARATE COMMON CORE FOR LEVEL 3

INSPECTION METHOD: VISUAL TESTING **LEVEL: 3**
SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Electromagnetic radiations

- 2.1.1 Characteristics of luminous spectra; intensity, colour, tone and frequency
- 2.1.2 Luminous sources; intensity of the luminous sources, photometric and radiometric measurements, illumination, luminous flux and luminance; experimental law of photometry
- 2.1.3 Fundamental laws for emission, transmission and absorption of light, interface phenomena, emissivity and reflectance
- 2.1.4 Role, importance and scheduling of visual testing
- 2.1.5 Geometrical optics, distortion, measurement
- 2.1.6 Errors of refraction and means of correction
  a) Myopia or short-sightedness, concave spherical glasses
  b) Hypermetropia or long sightedness, convex spherical glasses
  c) Astigmatism cylindrical lenses or contact lenses

SPECIFIC OBJECTIVES:

2.1 Given the instructor's explanations, the student will be able to:

a) describe the properties of light;
b) establish the characteristics of the electromagnetic spectra;
c) establish the range of the spectra corresponding to light;
d) define luminous sources of equal intensity;
e) define luminous flux;
f) explain the experimental law of photometry;
g) define the different units of illumination;
h) define the phenomena occurring when light passes through an interface;
i) explain concepts related to dispersion, diffraction, absorption and transmission of light;
j) explain emissivity and reflectance.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including an analysis of the graphic expression of application rules and principles, guided discussion and laboratory experiments.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, Tables and drawings
Laboratory material to demonstrate physico-chemical principles and Course notes.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 3**
SUBJECT: 3. VISION

CONTENTS:

---

3 1 Vision
- 3.1.1 Human eye; principal physiological and anatomical aspects, focus and resolution
- 3.1.2 Response of eye to luminous excitation, spectral sensitivity, perception of intensity, color and contrast, stereoscopic vision
- 3.1.3 Sensitivity thresholds, visual acuity, contrast and colour sensitivity, influence of intensity and luminance
- 3.1.4 Defects of vision

3.2 Fundamentals of optical physics applied to lenses, mirrors, prisms and optical systems

3.3 Types of blindness
- a) Night blindness
- b) Day blindness
- c) Colour blindness

3.4 Symptomatic disturbance
- a) Partial loss of vision
- b) Complete loss of vision

3.5 Injuries
- a) Thermal injuries
- b) Electrical injuries
- c) Radiation-induced injuries

SPECIFIC OBJECTIVES:

3.1 Given the instructor's explanations, the student will be able to:
- a) identify the different parts of the human eye explaining their functions;
- b) explain separation power and visual acuity;
- c) explain perception of intensity, colour and contrast;
- d) explain concepts of intensity and luminance;
- e) explain the stereoscopic viewing of the eye and near and far vision;
- f) explain the different possible defects of vision.

3. 2 Given the instructor's explanations, the student will be able to:
- a) explain the fundamental laws of optics;
- b) explain the main characteristics of types of lenses, prisms, mirrors and optical systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, optical devices and aids.

INSPECTION METHOD: VISUAL TESTING LEVEL: 3
SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.1 Illumination sources
- 4.1.1 Various types of illumination sources, various fixing apparatus and various accessories. Sources for polarized light
- 4.1.2 Lamps for ultraviolet radiation, lasers
- 4.1.3 Accessories for filtering and collimating light beam, measuring instruments for measuring light intensity (luximeters)

4.2 Visual aids; lenses, prisms, mirrors, compound lenses, stereoscopic loops, optical microscope, telescope and projectors

4.3 Image transmission
- 4.3.1 Fiber optics, acrylic and glass-fibers, transmission of image and transmission of light
- 4.3.2 Rigid and flexible endoscopes, endoscopes with micro T.V. systems block diagram

4.4 Micro alignment telescope

4.5 Digital camera

4.6 Equipment for monitoring
- a) Real time monitoring equipment
- b) mobile monitoring equipment
- c) vibration properties of materials
- d) vibration characteristics of structure
- e) methods for measuring the frequency

SPECIFIC OBJECTIVES:

4.1 Given the instructor's explanations, the student will be able to:
- a) explain values of light source emitters according to spectral quality of the radiation;
- b) explain the efficient and useful life of different sources of light;
- c) explain principles of operation and construction of various light sources;
- d) recognize the usefulness of various accessories for controlling light sources.

4.2 Given the instructor's explanations, the student will be able to:
- a) explain the characteristics of lenses, prisms and other optical systems;
- b) explain characteristics of compound lenses, stereoscopic loops, microscopes, telescopes and projectors;
- c) select the suitable equipment for the test.

4.3 Given the instructor's explanations, the student will be able to:
- a) explain construction characteristics of various types of endoscopes; explain the combined system for image transmission; explain the applications of T.V. systems.

4.4 Given the instructor's explanations, the student will be able to explain the construction and use of a micro alignment telescope.

4.5 Given the instructor's explanations, the student will be able to explain the working of a digital camera.

4.6 Given the instructor's explanations, the student will be able to explain various types of monitoring equipment.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical student work and solution of problems.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Light sources,
Visual aids,
Image transmitting equipment,
Sample pieces.

INSPECTION METHOD: VISUAL TESTING LEVEL: 3
SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

5.1 Surface preparation
5.2 Illuminating conditions, intensity, angle, distance, type of illumination
5.3 Viewing techniques; direct, indirect and image transmission
5.3.1 Parameters for the selection and operation of the various techniques
5.4 Programming the sequences of viewing, systems for identification of the areas to be examined, assessing relevance of features to be detected, evaluation of features against fitness-for-purpose aspects
5.5 Control and calibration of the test
5.5.1 Jaeger charts for the control of near and far vision, JIS charts for colour blindness
5.5.2 Reference blocks with calibrations, reference block with cracks, control of perceptibility in accordance with procedures
5.5.3 Maintenance and control of equipment and accessories, calibration of luximeter or photometer, specific objectives
5.6 Rules for the use, maintenance and control for equipment and accessories, work in the laboratory and in the field
5.7 Visual and optical test procedures
5.8 Selection and specification of equipment for the test

SPECIFIC OBJECTIVES:

Given the instructor's explanations, the student will be able to:

a) establish all necessary preparations of surface for test;
b) establish at selected necessary parameters related to illumination, angle, distance, etc., needed to perform the test;
c) establish the technique to be applied;
d) establish the sequence of operation and system of identification for the test;
e) explain the use of Jaeger and JIS charts; procedure writing;
f) explain the use of reference blocks for the control of perceptibility;
g) establish rules for the use, maintenance and control of equipment and accessories;
h) calibrate luximeter and photometers;
i) select all equipment necessary to perform a specific test;
j) assist and advise in drafting acceptance criteria.
k)

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical student work and solution of problems.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos, course notes, sample pieces, light sources, Jaeger and JIS charts, and reference blocks.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 3**
SUBJECT: 6. IMAGE RECORDING

CONTENTS:

6.1 Photographic recording
- 6.1.1 Fundamentals of photography and photographic cameras
- 6.1.2 Various types of photographic cameras. Macro and telephotography.
- 6.1.3 Various types of film. Spectral sensitivity. Contrast, latitude and grain

6.2 Replicas
- 6.2.1 Various types of replica: positive and negative, macro and micro resolutions
- 6.2.2 Materials employed on the different techniques
- 6.2.3 Conditioning of replicas and requirements for their observation and conservation

6.3 Film digitization and image processing.

SPECIFIC OBJECTIVES:

---

6. Given the instructor's explanations, the student will be able to:
   a) explain the characteristics of the various types of photographic cameras;
   b) list the different types of photographic film with reference to sensitivity, contrast and grain;
   c) describe the various types of replica and explain their applications;
   d) detail the materials used in the different techniques
   e)

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including student’s practical work with different photographic cameras and film types.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes,
Various types of cameras,
Replicas, Replica materials and Sample pieces.

INSPECTION METHOD: VISUAL TESTING LEVEL: 3
SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

7.1 Examination specifications
- 7.1.1 Function of design engineering
- 7.1.2 Design and building codes
- 7.1.3 ASME code (or other equivalent codes)

7.2 Standards specific to visual inspection
- 7.2.1 National and international standards (ASTM, DIN, MIL, IRAM)
- 7.2.2 Interpretation of specifications, codes and standards

7.3 Testing procedures
- 7.3.1 Formulation of test procedures
- 7.3.2 General and specific procedures

7.4 General rules for safety in industrial establishments

SPECIFIC OBJECTIVES:

7.1 Given the instructor's explanations, the student will be able to interpret, analyze and apply specifications for examination prepared by design engineers or called for in codes of practice.

7.2 Given the instructor's explanations, the student will be able to analyze, evaluate and apply visual inspection according to national and international standards.

7.3 Given the instructor's explanations, the student will be able to develop, evaluate and apply written procedures for visual inspection, conforming to externally imposed requirements and those imposed by the specimens, equipment available and work environments.

7.4 Given the instructor's explanations, the student will be able to apply good safety practices in the application of visual inspection.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion, practical exercises on the preparation and interpretation of procedures.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Codes (ASME, ASTM, DIN, API, BSI, JIS, etc.),
Formulae for data registration,
Work pieces,
Test procedures and examples of written instructions.

INSPECTION METHOD: VISUAL TESTING **LEVEL: 3**
SUBJECT: 8. SAFETY ASPECTS

CONTENTS:

8.1 Safety and environmental consideration
- 8.1.1 Safety for visual and optical tests
  - a) Need for safety
  - b) Laser hazards
  - c) Infrared hazards
  - d) Ultraviolet hazards
  - e) Photosensitizers
  - f) Damage to the retina
  - g) Thermal factor
  - h) Blue hazards
  - i) Eye protection filters

8.2 Industrial safety standards

8.3 Visual and optical testing environment
- a) Cleanliness
- b) Texture and reflectance
- c) Lighting for V. T.
- d) Light intensities
- e) Vision in the testing environment

8.4 Visual safety recommendations

8.5 Implementation of industrial safety standards in facilities and equipment and in their operation

8.6 Hazards of using toxic and inflammable materials

8.7 Materials, accessories and equipment for the protection of persons and facilities

---

SPECIFIC OBJECTIVES:

Given the instructor’s explanations, the student will be able to describe the safety conditions under which the test should be carried out and be able to apply good safety practices.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,
Course notes
Safety standards
Safety equipment & accessories.

INSPECTION METHOD: VISUAL TESTING LEVEL: 3
SUBJECT: 9. APPLICATIONS

CONTENTS:

9.1 Applications; VT during manufacturing process
- 9.1.1 Applications of visual and optical tests in the electric power industries
- 9.1.2 Joining processes, acceptance standards, recording and reporting visual test results
- 9.1.3 Specific visual inspection applications, pumps, values, bolting, forging, rolled stock and casting
- 9.1.4 Applications of visual and optical tests in the transportation industries, optical tests in the automobile industries, optically aided visual testing of aircraft structure

9.2 Interface of visual testing with other NDT methods, visual testing of liquid penetrant, leak testing, radiographic testing, magnetic particle testing, ultrasonic testing, etc.

9.3 Applications of photography in visual testing, photographs as a permanent record, photogrammetry for documenting the condition of petrochemical furnaces conclusions

9.4 Visual testing of ceramics

9.5 Visual testing of threads in oil industry tubular goods

9.6 Visual testing of composite materials

9.7 Visual testing of micro electronic components

9.8 Visual and optical testing in metal industry

9.9 In-service inspection
- 9.9.1 ISI of plants in the light of call up maintenance card
- 9.9.2 Displacement measurement of moving parts of the components i.e. pumps compressors, motors, etc.
- 9.9.3 Optical vibration monitoring
  a) Static measurement
  b) Dynamic measurement

SPECIFIC OBJECTIVES:

Given the instructor’s explanations, the student will be able to understand different applications of different visual testing techniques.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos and Course notes.

11. APPENDIX A – CODE OF ETHICS FOR NDT PERSONNEL

The following Code of Ethics is for individuals certified to ISO9712-2012 or equivalent standards as part of this current TECDOC 626. These individuals shall precept the personal integrity and professional competence according to international codes and standards (recommended for Level 1 and 2, compulsory for certified Level 3 personnel).

All certified to Levels 1 or 2 or 3, active or retirees, individuals or companies, members or trainees, when providing their professional duties, shall:

1 Perform their professional duties and show responsibilities in order to protect the human life, health, physical environment, property and welfare of public, to maintain integrity and high standards of skills and practices in the profession of Non-destructive testing (NDT).
2 Act at all time to uphold the integrity and dignity, with obligation to act with complete integrity in professional matters for each client or employer; shall be honest and impartial; and shall serve the public, clients and employer with devotion.
3 To adhere to laws, regulations and acts related to the application of NDT, and under all situations putting responsibility to these laws, regulations exceeding responsibilities to profession, individual and organizational interests.
4 Conduct them in a responsible manner and utilize fair and equitable practices in dealing with colleagues, client and associates.
5 Accept professional obligations only for those areas for which they are competent. Undertake to perform assignments only when qualified by training and experience in specific technical fields involved and express an opinion as a technical witness before any court, commission or other tribunal, only when such opinion is founded upon adequate knowledge of the facts in issue, upon an honest conviction of the accuracy or property of the testimony.
6 Provide professional advice, express opinion or make statements in an objective and truthful manner to the best of their ability and on the basis of adequate knowledge of the facts in issues upon a background of technical competence in the subject matter and upon honest conviction of the accuracy and propriety of the testimony.
7 Refrain from making unjustified statements or from performing unethical acts. Shall not solicit or accept financial or other valuable consideration, directly or indirectly, from material or equipment suppliers of products or other parties dealing with the client or employer.
8 Refuse to accept responsibility for the design, report or statement involved and be completely objective in any professional report, would, or testimony, avoiding any omission which would, or reasonable would, lead to fallacious inference, finding, or misrepresentation.
9 Not to sign documents, reports or instructions for work for which he/she does not have personal knowledge and direct technical supervisory control and responsibility
10 Accept responsibility for all work carried out by them or others under their supervision.
11 Indicate to the employer or client any adverse consequences which may result from over-ruling of their technical judgment by a non-technical authority which could influence his/her judgment or quality of services.
12 Protect to the fullest extent, consistent with well-being of the public any information given them in confidence by an employer, colleague, client or member of the public.
13 Strive to maintain their proficiency and professional development by updating g their technical knowledge as required to properly perform and shall actively assist and encourage other NDT personnel to advance their knowledge and experience.
14 To continuously improving professional capability and actively assisting and encouraging

other NDT personnel to improve their knowledge and experience.

12. APPENDIX B - PRACTICAL WORKSHOPS

1.1 Background

The aim of the Practical Training Workshop is to provide the NDT trainees and inspectors with an opportunity to acquire a sound basis in detection and evaluation of various defects and discontinuities over a wide range of specimens. Also, the aim is to provide specimens from various processes and of different material types. It is designed to assist the student in acquiring practical experience and skills in interpreting results over a short period of time which would normally take weeks, months or years to accomplish.

This appendix includes a suggested workshop structure for the ultrasonic test method. Users of this publication are encouraged to develop equivalent structures for other test methods as required.

1.2 Objective

The objective of the practical training workshop is to provide students with the opportunity to inspect record and evaluate numerous test specimens with known discontinuities and defects.

1.3 Scope

The focus of the practical workshop course is on interpretation of test results on specimens from industry and not artificial defects where possible.

1.4 Structure

The following section provides an overview of the standard syllabus and its structure, prerequisites and learning objective, and suggests duration for each part.

The standard syllabus of the Practical Training Workshop is divided into various parts and each part is divided into modules. For each part, the prerequisite is indicated as well as the general learning objective. Each module is described by the content and the link to the training material and the reference publication. For each part, a list of practical training sessions is suggested, i.e. practical lab exercise.

Table 1 provides the prerequisites, general learning objectives and suggested sector applications. The duration and number of inspections will vary depending on the students prior experience. The prerequisite for the course is that the participants should have successfully completed the classroom requirements of the TECDOC 628 or equivalent training criteria.

Table 1: Example of workshop for ultrasonic testing

Project No.	Project	Prerequisite	Objective	Duration
1	Establish sweep and sweep delay	Level 1 theory	Calibrate the sweep and sweep delay using multiple back echoes	
2	Create a distance amplitude curve	Level 1 theory	Construct a DAC for a normal beam contact method	
3	Determine near zone length	Level 1 theory	Determine mathematical and practical the near zone	
4	Calibrate for angle beam inspection	Level 1 theory	Calibrate the flaw detector and measure the angle beam characteristics using an IIW block	
5	Determine sound path and skip distance	Level 1 theory	Calibrate and measure sound path and skip distance for a given plate thickness	
6	Create an angle beam distance amplitude curve	Level 1 theory	Create an angle beam distance calibration curve	
7	Check vertical linearity of an A-scan	Level 1 theory	Determine if the vertical linearity of the flaw detector is acceptable.	
8	Check horizontal linearity of an A-scan	Level 1 theory	Determine if the horizontal linearity of the flaw detector is acceptable.	
9	Check near surface and far surface resolution	Level 1 theory	Determine the near and far surface resolution limits	
10	Determine signal to noise ratio	Level 1 theory	Determine signal to noise ratio of the system.	
11	Determine angle beam profile	Level 1 theory	Determine the angle beam profile in the vertical and horizontal planes.	
	Practical Assignment – Thickness	Level 1* and/or 2 theory	Calibrate longitudinal transducer to display 250 mm using IIW block, measure the thickness of numerous plates Level 1 – record results Level 2 – record and interpret	
	Practical Assignment – Plate scan	Level 1* and/or 2 theory	Calibrate longitudinal transducer to display 100 mm using IIW block, inspect a plate sample for lamination Level 1 – record results Level 2 – record and intrepret	
	Practical Assignment – Immersion	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment - Casting	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment – Forging	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	

	Practical Assignment - T weld	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment – Butt Weld	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment – Transition Weld	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment – Extrusion	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment - Plate Weld	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment – Pipe	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	
	Practical Assignment – Manufacturing and In-service	Level 1* and/or 2 theory	Inspect a specimen sample for defect type, location and orientation: Level 1 - record results Level 2 – record and interpret	

* Note: A Level 1 student need only to record test results

13. APPENDIX C - WEIGHING OF LEVEL 3 PROCEDURE WRITING

Part 1 - General: (8% of total mark of the procedure)

a) Scope (field of application, product)
b) Document control
c) Normative references and complimentary information

Part 2 – NDT Personnel (2% of total mark of the procedure)

Part 3 – Material and equipment: (20% of total mark)

a) Main NDT equipment (incl defining calibration status and pre-test serviceability checks)
b) Ancillary equipment (reference and calibration bocks, consumables, measuring equipment, view aids etc.)

Part 4 – Test piece: (5% of total mark of the procedure)

a) Physical conditions and surface preparation (temperature, access, removal of protective coating, roughness, etc.)
b) Description of area or volume to be tested, including reference datum
c) Discontinuities sought

Part 5 – Performance of the test: (40% of total mark for procedure)

a) NDT method(s) and technique(s) to be used
b) Setting up the apparatus
c) Conducting the test (including reference to the NDT instructions)
d) Characterization of discontinuities

Part 6 – Acceptance criteria (7% of total mark of the procedure)

Part 7 – Post-test procedure: (3% of total mark of the procedure)

a) Disposition of non-conforming product (labeling, segregation)
b) Restoration of protective coating (where required)

Part 8 - Producing the test report (5% of total mark of the procedure)

Part 9 – Overall presentation (10% of total mark)

Total for the procedure writing 100%

Note 1: the Written procedure is 50% of the total mark for Main Method examination and to replace the Practical examination for Level 3

Note 2: tThe Certification body may replace the drafting of a procedure with the critical analysis of an existing NDT method (Table 7, Part F, ISO9712:2012) but this practice is strongly not recommended for most of Member States of IAEA.

14. APPENDIX D - SAMPLES OF NDT REPORTS (FOR UT, RT, MT AND PT)

Company (NDT Lab) name

RADIOGRAPHIC INSPECTION REPORT

DATE: 16.04.2011
PAGE: 1
REPORT NR : PLRT 44

CUSTOMER	XXXXXX	SHOOTING STAND.	ASME Sec.V	FILM BRAND & TYPE	KODAK MX 125
TEST LOCATION	NAVOYI SITE	SHOOTING TECH.	DOUBLE WALL SINGLE IMAGE	SOURCE TYPE	Ir 192
JOB TYPE	PIPE LINE	MATERIAL	CS	SOURCE DIMENS.	3X2 mm.
ACCEPTANCE CRIT.	ASME B 31.1	min IQN / IQI	ASTM 1 B	SCREEN	Pb

ACTIVITY	63,30 Ci	FFD	Φ	EXPOSURE TIME	2.2 MIN	FILM DENSITY	2 ~ 4

SERIAL	WELD NUMBER			EXAMINATED AREA	WELDER	IQI / DEN	DIA / THICK.	TYPE OF DEFECT	RESURET	NOTES
1	10 LBC	26 BR 010 /sh1/1	BW 12	0-15	A06	6/3.0	6''/7,11		OK	
2				15-30	A06	6/3.0			OK	
3				30-45	A06	6/3.0			OK	
4				45-0	A06	6/3.0			OK	
5	-	-	-	-	-	-	-	-	-	
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Aa 2011	POROSITY	Ba 3012	SLAG INCLUSION	Db 402	INCOMPLATE PENETR.	E 100	CRACK	OK	ACCEPT
Ab 2016	WORM HOLES	Bb 3011	SLAG LINE	Fa 304	EXCESSIVE PENETRATION	Si	MISALIGNMENT	REP	REPAIR
Ac 2013	POROSITY GROUP	C 401	LACK OF FUSION	Fb 514	POOR PROFILE	H 304	METALLIC INCLUSION	RS	RESHOOT
Ad 2014	ALIGNET POROSITY	Da 515	ROOT CONCAVITY	Fc 301	UNDERCUT	Ff	FILM DEFECT	EX	EXTRA FILM

10X16	10X24	10X48	NDT specialist	COSTUMER	AUTHORYTY
00	04	00	/DATE: XXXXX	DATE:	DATE:

ULTRASONIC TEST REPORT # **Company (NDT Lab) name**

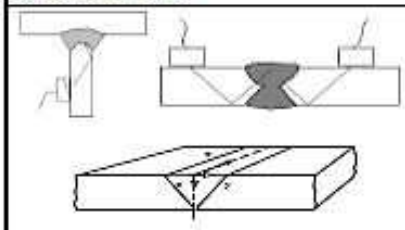
CUSTOMER	XXXXXXXXX	REPORT NUMBER	UT RN 063
PROJECT	NAVOI CCPP	INSPECTION AREA	WELD SEAM
JOB NAME	CC PP	DRAWING NUMBER	10-NAA-10-BR-010 SHEET:2

TEST INFORMATION

TEST CONDITION	Checking Date	Before Testing
	Name of Equipment	GE Krautkrammer USM 35 X
	Couplant Medium	Lomex Ultrasound Gel
	Surface Condition	As it is
TESTING PROCEDURE	Test Standart	ASME Sec. V Article IV
	Name of probe	Krautkrammer / 70-60-45-0
	Crystal dimensions	8 X 9 mm.
	Frequency	4 MHz
	Probe Angle	60°-70°-45°-0°
	Distance Calibration	100 mm.
	Calibration Block	K1-K2
	Sensitivity Calibration	DAC 3 mm.
	Sensitivity Block	Cal. Block
	Base Gain	34 (dB)
	Addition Gain	6 (dB)
	Record Gain	42 (dB)

WELDER	Dimensions	Material	Acceptance Criteria	Test Scope	Heat Treatment
A 26	8''/ 10,31 mm	A106 Gr.B	ASME Sec. VIII	% 100	

TEST SKECH



	X	Y	Z	ΔX	ΔVu	Explanation
1	*	*	*	*	*	FW 31 ACC
2	*	*	*	*	*	*

Single side examination has been applied due to restricted access to the weld.Additionally (0°) straight beam examination was conducted when the weld external reinforcement has been flush ground and prepared in one level with base metal.

RESULT ACCEPTABLE

NDT specialist	CUSTOMER	AUTHORITY
DATE: XXXXXXX	DATE: XXXXXXX	DATE: XXXXXXX

Company (NDT Lab) name

MAGNETIC PARTICLE TEST REPORT

CUSTOMER	XXXXX	REPORT NUMBER	MT RN 001
PROJECT	XXXXX	INSPECTION AREA	WELDING + HAZ
JOB NAME	OVERHEAD CRANE GIRDER	DRAWING NUMBER	XXXXXXX

TECNICAL INFORMATIONS

TEST STANDART	*ASME Sec.V Article 7*	SURFACE CONDITION	*As it is*
ACCEPTANCE CRITERIA	*ASME Sec. B 31.1*	HEAT TREATMENT	*NONE*
EXTEND OF TEST	*% 10*	PRODUCT FORM	*WELDING*
MAGNET TYPE & BRAND	*Handling – Universal*	MAGNET NAME	*Magnaflux yoke*
MAGNET HOLD POWER	*4.5 KGF*	MEDIUM LIGHT INTEN.	*800 LUX*
TEST TECHNIC (UV or CONTRAST)	*CONTRAST*	MATERIAL	*CS*
CURRENT TYPE (AC OR DC)	*AC*	FIELD STRENGTH	*3-3.5 kA/m*

INSPECTION INFORMATIONS

	PART NAME	TEST DATE	RESULT	EXPLANATION
1	OVERHEAD CRANE GIRDER	XXXXX	OK	
2	% 10 MPI TEST			
3	--	--	--	--
4				
5				
6				
7				
8				
9				
10				

NDT SPECIALIST	CUSTOMER	AUTHORYTY
DATE: XXXXX	DATE: XXXXX	DATE: XXXXX

Company (NDT Lab) name

LIQUID PENETRANT TEST REPORT

CUSTOMER	XXXXXXX	REPORT NUMBER	RN:PT..003
PROJECT	XXXXXXX	INSPECTION AREA	WELDING + HAZ
JOB NAME	PIPE LINE	DRAWING NUMBER	10 LBC 20 BR 020
TECNICAL INFORMATIONS			
TEST STANDART	ASME Sec.V Article 6	SURFACE CONDITION	As it is
ACCEPTANCE CRITERIA	ASME Sec. B31.1	HEAT TREATMENT	NONE
EXTEND OF TEST	% 100	PRODUCT FORM	WELD SEAM
EQUIPMENT	MAGNAFLUXSKL-SP1/SKD-S2/SKC-S	SURFACE TEMPERATURE	10 < T <50 °C
PENETRANT SYSTEM	Tip II Metod C Form d	MEDIUM LIGHT INTEN.	800 LUX
TEST TECHNIC (UV or CONTRAST)	Contrast	MATERIAL	CS
APPLICATION TIMES	SKL-SP1 15 dk. SKD-S2 0-5 dk.	EVALUATION TIME	10 dk.

INSPECTION INFORMATIONS

	WELD NO	SHEET	WELDER	DIA/ THICKNESS	DATE	RESULT	EXPLANATION
1	BR SW 15	2/5	A 07 / A08	10"/12,70	04.04.2011	OK	
2	-	-	-	-	-	-	
3							
4							
5							
6							
7							
8							
9							
10							

NDT SPECIALIST	CUSTOMER	AUTHORYTY
DATE: XXXXXXX	DATE: XXXXXXX	DATE: XXXXXXX

15. APPENDIX E - ADVANCED METHODS

The following sections described suggested course content for a number of advanced NDT methods. There may not be sufficient training experience in these methods to assign hours or methodology, but the curricula provide a body of knowledge for the development of training courses.

ISO Standard 9712 and ISO TR 25107 may contain detailed information on the current requirements for training hours.

X.1 ACOUSTIC EMISSION TESTING

Level 1:

1. Principles of acoustic emission testing
- 1.1 Characteristics of acoustic emission
- 1.2 Sources of acoustic emission
- 1.3 Wave propagation; introduction
- 1.4 Repeated loadings: Kaiser and Felicity effects and Felicity ratio
- 1.5 Terminology (refer to AE Glossary, ASTM E1316)

2. Sensing the AE wave
- 2.1 Sensors
- 2.2 Sensor attachment

3. Instrumentation and signal processing
- 1.1 Cables
- 1.2 Signal conditioning
- 1.3 Signal detection
- 1.4 Signal processing
- 1.5 Source location techniques
- 1.6 Acoustic emission test system
- 1.7 Accessory techniques

4. Acoustic emission test techniques
- 4.1 Equipment calibration and setup for test
- 4.2 Loading procedures
- 4.3 Data display
- 4.4 Noise sources and pre-test identification techniques
- 4.5 Precautions against noise
- 4.6 Data interpretation and evaluation; introduction
- 4.7 Reports

5. Codes, standards and procedures
- 5.1 Guide-type standards (glossaries, calibration etc.)
- 5.2 Standardized/codified AE test procedures
- 5.3 User-developed test procedures

6. Applications of acoustic emission testing
- 6.1 Laboratory studies (material characterization)
- 6.2 Structural applications.

Level 2:

1. Principles of acoustic emission testing
- 1.1 Characteristics of acoustic emission testing
- 1.2 Materials and deformation
- 1.3 Sources of acoustic emission
- 1.4 Wave propagation
- 1.5 Attenuation
- 1.6 Kaiser and Felicity effects, and Felicity Ratio
- 1.7 Terminology (refer to AE Glossary, ASTM E1316)

2. Sensing the AE wave
- 2.1 Transducing processes (piezoelectricity, etc.)
- 2.2 Sensors
- 2.3 Sensor attachment
- 2.4 Sensor utilization

3. Instrumentation and signal processing
- 3.1 Cables
- 3.2 Signal conditioning
- 3.3 Signal detection
- 3.4 Signal processing
- 3.5 Source location techniques
- 3.6 Acoustic emission test systems
- 3.7 Accessory techniques
- 3.8 Advanced signal processing techniques

4. Acoustic emission test techniques
- 4.1 Factors affecting test equipment selection
- 4.2 Equipment calibration and setup for test
- 4.3 Loading procedures
- 4.4 Special test procedures
- 4.5 Data display
- 4.6 Noise sources and pre-test identification techniques
- 4.7 Precautions against noise
- 4.8 Data interpretation
- 4.9 Data evaluation
- 4.10 Reports

5. Codes, standards, procedures and societies
- 5.1 Guide-type standards (glossaries, calibration, etc.)
- 5.2 Standardized/codified AE test procedures
- 5.3 User-developed test procedures
- 5.4 Societies active in AE

6. Applications of acoustic emission testing
- 6.1 Laboratory studies (material characterization)
- 6.2 Structural applications

Level 3:

1. Principles and theory

1.1 Characteristics of acoustic emission testing
1.2 Materials and deformation
1.3 Sources of acoustic emission
1.4 Wave propagation

2. Equipment and materials

2.1 Transducing processes (piezoelectricity), etc.
2.2 Sensors
2.3 Sensor attachment
2.4 Sensor utilization
2.5 Simulated AE sources
2.6 Cables
2.7 Signal conditioning
2.8 Signal detection
2.9 Signal processing
2.10 Source location
2.11 Advanced signal processing
2.12 Acoustic emission test systems
2.13 Accessory materials
2.14 Factors affecting test equipment selection

3. Techniques

3.1 Equipment calibration and setup for test
3.2 Establishing loading procedures
3.3 Precautions against noise
3.4 Special test procedures
3.5 Data display

4. Interpretation and evaluation

4.1 Data interpretation
4.2 Data evaluation
4.3 Reports

5. Procedures

5.1 Guide-type standards (glossaries, calibration, etc.)
5.2 Standardized/codified AE test procedures
5.3 User-developed test procedures
5.4 Societies active in AE
5.5 Interpretation of codes, standards, and procedures
5.6 Developing and writing AE test procedures
5.7 Training and examining level 1 and 2 NDT personnel

6. Safety and health

6.1 Hazards associated with structural failure
6.2 Other hazards associated with AE testing
6.3 Importance of local regulations

7. Applications

7.1 Laboratory studies (material characterization)
7.2 Structural applications

X.2 NEUTRON RADIOGRAPHIC TESTING

Level 1:

1. Personnel monitoring
- 1.1 Personnel monitoring dosimeters
- 1.2 Permissible personnel exposure limits

2. Radiation survey instruments
- 2.1 Types of instruments
- 2.2 Reading and interpreting meter indication
- 2.3 Calibration frequency
- 2.4 Calibration expiry; actions to be taken
- 2.5 Battery check; importance

3. Radiation area surveys
- 3.1 Type and quantity of radiation
- 3.2 Posting
- 3.3 Establishment of time limits

4. Radioactivity
- 4.1 Radioactive components (fuel, sources, etc)
- 4.2 Induced radioactivity due to neutron radiography

5. Radiation-area work practices: safety
- 5.1 Use of time, shielding and distance to reduce personnel radiation exposure
- 5.2 Restricted areas
- 5.3 Radioactive contamination
- 5.4 Specific procedures

6. Explosive-device safety
- 6.1 Static electricity
- 6.2 Grounding devices
- 6.3 Clothing requirements
- 6.4 Handling and storage requirements and procedures
- 6.5 Shipping and receiving procedures

7. State and Federal regulations
- 7.1 Nuclear Regulatory Commission (NRC) and agreement states authority
- 7.2 Occupational Safety and Health Administration (OSHA)
- 7.3 Department of Transportation (DOT)
- 7.5 State and Federal explosive-licensing requirements

8. Introduction
- 8.1 History of industrial neutron radiography
- 8.2 General principles of examination of materials by penetrating radiation
- 8.3 Relationship of penetrating neutron radiation, radiography, and radiometry
- 8.4 Comparison with other NDT methods, particularly with X-rays and gamma ray radiography
- 8.5 General areas of application

9. Physical principles

9.1 Sources for neutron radiography (general description)
9.2 Interaction between neutrons and matter
9.3 Neutron radiography techniques
9.4 Glossary of terms and units of measure

10. Radiation sources for neutrons (specific description)

10.1 Reactors
10.2 Accelerators
10.3 Isotopic sources

11. Personnel safety and radiation protection

11.1 Hazards of excessive exposure
11.2 Methods of controlling radiation dose
11.3 Specific equipment requirements
11.4 Radiation work procedures
11.5 Federal, state and local regulations

12. Radiation detection and imaging

12.1 Converter screens
12.2 Film; principles of operation
12.3 Track-etch detectors

13. Neutron radiographic process: basic imaging considerations

13.1 Definition of sensitivity (including penetrameters)
13.2 Contrast and definition
13.3 Geometric principles
13.4 Generation and control of scatter
13.5 Choice of neutron source
13.6 Choice of film
13.7 Use of exposure curves
13.8 Cause and correction of unsatisfactory radiographs
13.9 Arithmetic of exposure

14. Test result interpretation

14.1 Relationship between X-ray and neutrons
14.2 Effects on measurement and interpretation of test
14.3 Administrative control of test quality by interpreter
14.4 Familiarization with image

Level 2:

1. Introduction

1.1 General principles of examination of materials by penetrating radiation
1.2 Relationship of penetrating neutron radiation, radiography, and radiometry
1.3 Comparison with other methods, particularly with X-Rays and gamma rays
1.4 Specific areas of application in industry

2. Review of physical principles

2.1 Nature of penetrating radiation (all types)
2.2 Interaction between penetrating radiation and matter (neutron and gamma ray)
2.3 Glossary of terms and units of measure

3. Radiation sources for neutrons
- 3.1 Neutron sources — general

4. Radiation detection
- 4.1 Imaging
- 4.2 Non-imaging devices

5. Personnel safety and radiation protection
- 5.1 Hazards of excessive exposure
- 5.2 Methods of controlling accumulated radiation dose
- 5.3 Specific equipment requirements
- 5.4 Operation and emergency procedures
- 5.5 Federal, state, and local regulations

6. Neutron radiographic process
- 6.1 Basic neutron-imaging considerations
- 6.2 Miscellaneous applications

7. Test result interpretation
- 7.1 Basic factors
- 7.2 Material considerations
- 7.3 Codes, standards, specifications, and procedures

Level 3:

1. Principles; theory
- 1.1 Nature of penetrating radiation
- 1.2 Interaction between penetrating radiation and matter
- 1.3 Neutron radiography
- 1.4 Radiometry

2. Equipment; materials
- 2.1 Sources of neutrons
- 2.2 Radiation detectors
- 2.3 Non-imaging devices

3. Techniques; calibrations
- 3.1 Blocking and filtering
- 3.2 Multi-film technique
- 3.3 Enlargement and projecting
- 3.4 Stereoradiography
- 3.5 Triangulation methods
- 3.6 Autoradiography
- 3.7 Flash radiography
- 3.8 In-motion radiography
- 3.9 Fluoroscopy
- 3.10 Electron emission radiography
- 3.11 Microradiography
- 3.12 Laminography (tomography)
- 3.13 Control of diffraction effects
- 3.14 Panoramic exposures
- 3.15 Gauging
- 3.16 Real time imaging
- 3.17 Image analysis techniques

4. Interpretation/evaluation

4.1 Radiographic interpretation

5. Procedures

5.1 The radiographic process

5.2 Film processing

5.3 Viewing of radiographs

5.4 Judging radiographic quality

6. Safety and health

6.1 Personnel safety and radiation hazards

X.3 THERMAL/INFRARED TESTING

Level 1:

1. The nature and measurement of heat
- 1.1 Instrumentation
- 1.2 Scales and conversions

2. Temperature and its measurement
- 2.1 Instrumentation
- 2.2 Scales and conversions

3. Heat transfer modes
- 3.1 Heat conduction
- 3.2 Heat convection
- 3.3 Heat radiation

4. Radiosity concepts
- 4.1 Reflectivity
- 4.2 Transmissivity
- 4.3 Absorpitivity
- 4.4 Emissitity
- 4.5 Infrared radiometry and imaging
- 4.6 Spatial resolution concepts
- 4.7 Error potential in radiant measurements (an overview)

5. Introduction
- 5.1 Thermography
- 5.2 Working of infrared imagers
- 5.3 Differences among imagers and alternative equipment
- 5.4 Operation of infrared thermal imager
- 5.5 Operation of support equipment for infrared surveys

6. Checking equipment calibration with blackbody references

7. Infrared image and documentation quality
- 7.1 Elements of a good infrared image
- 7.2 Recording

8. Support data collection
- 8.1 Environmental data
- 8.2 Emissivity
- 8.3 Surface reference temperatures
- 8.4 Identification and others

9. Detection of thermal anomalies resulting from difference in thermal resistance (quasi steady-state heat flow)
- 9.1 Large surface-to-ambient temperature difference
- 9.2 Small surface-to-ambient temperature difference

10. Detection of thermal anomalies resulting from differences in thermal capacitance, using system or environmental heat cycles

11. Detection of thermal anomalies resulting from differences in physical state

12. Detection of thermal anomalies resulting from fluid flow problems

13. Detection of thermal anomalies resulting from friction

14. Detection of thermal anomalies resulting from non-homogeneous exothermic or endothermic conditions

15. Field quantification of point temperatures

15.1 Simple techniques for emissivity
15.2 Typical (high emissivity) applications
15.3 Special problem of low emissivity applications.

Level 2:

1. Basic calculations in the three modes of heat transfer

1.1 Conduction; principles and elementary calculations
1.2 Convention; principles and elementary calculations
1.3 Radiation; principles and elementary calculations

2. The infrared spectrum

2.1 Planck's law/curves
2.2 Effects due to semi-transparent windows and/or gasses
2.3 Filters

3. Radiosity problems

3.1 Black bodies; theory and concepts
3.2 Emissivity problems
3.3 Calculation of emissivity, reflectivity and transmissivity (practical use of Kirchoff's law)
3.4 Reflectivity problem
3.5 Transmissivity problem

4. Resolution tests and calculations

4.1 IFOV and FOV measurement and calculations
4.2 MRTD measurements and calculations
4.3 Slit response function; measurement, calculations, interpretations and comparisons
4.4 Resolution vs. lens and distance
4.5 Dynamic range
4.6 Data acquisition rate/data density
4.7 Frame rate and field rate
4.8 Image data density

5. Infrared measurements (quantification)

5.1 Simple infrared energy measurement
5.2 Quantifying the emissivity of the target surface
5.3 Quantifying temperature profiles
5.4 Computer processing to enhance imager data

6. High-speed data collection

6.1 Producing accurate images of transient processes
6.2 Recording accurate images of transient processes
6.3 Equipment selection and operation for imaging from moving vehicles

7. Special equipment for "active" techniques

7.1 Hot or cold fluid energy sources
7.2 Heat lamp energy sources
7.3 Flash lamp energy sources
7.4 Electromagnetic induction
7.5 Laser energy sources

8. Reports and documentation
- 8.1 Calibration requirements and records
- 8.2 Report data requirements
- 8.3 Preparation of reports

9. Temperature measurement applications
- 9.1 Isotherms/alarm levels; personnel safety audits, etc.
- 9.2 Profiles

10. Energy loss analysis applications
- 10.1 Conduction losses through envelopes
- 10.2 Mass-transfer heat exchange (air or other flows into or out of the system)

11. "Active" applications
- 11.1 Insulation flaws
- 11.2 De-lamination of composites
- 11.3 Bond quality of coatings
- 11.4 Location of high heat-capacity components

12. Filtered applications
- 12.1 Sunlight
- 12.2 Furnace interiors
- 12.3 Semi-transparent targets

13. Transient applications
- 13.1 Imaging a rapidly moving process
- 13.2 Imaging from a vehicle

Level 3:

1. Principles/theory
- 1.1 Conduction
- 1.2 Convection
- 1.3 Radiation
- 1.4 Nature of heat and heat flow
- 1.5 Temperature measurements principles
- 1.6 Proper selection of Thermal/Infrared testing (TIR) as technique of choice

2. Equipment and materials
- 2.1 Temperature measurement equipment
- 2.2 Heat flux indicators
- 2.3 Performance parameters of non-contact devices

3. Techniques
- 3.1 Contact temperature indicators
- 3.2 Non-contact pyrometers
- 3.3 Infrared line scanners
- 3.4 Thermal/Infrared imaging
- 3.5 Heat flux indicators
- 3.6 Exothermic or endothermic investigations
- 3.7 Friction investigations
- 3.8 Fluid flow investigations
- 3.9 Thermal resistance (steady state heat flow) investigations
- 3.10 Thermal capacitance investigations

4. Interpretation/evaluation

4.1 Exothermic or endothermic processes
4.2 Friction
4.3 Fluid flow
4.4 Differences in thermal resistance (steady state heat flow)
4.5 Thermal capacitance

5. Procedures

5.1 Existing codes and standards
5.2 Elements of thermal/infrared testing job procedure development

6. Safety and health

6.1 Safety responsibility and authority
6.2 Safety for personnel
6.3 Safety for client and facilities
6.4 Safety for testing equipment

B.4 VIBRATION ANALYSIS

Level 1:

1. Introduction
- 1.1 Brief history of NDT and vibration analysis
- 1.2 The purpose of vibration analysis
- 1.3 Basic principles of vibration analysis
- 1.4 Basic terminology of vibration analysis

2. Transducers
- 2.1 Types
- 2.2 Applications
- 2.3 Mounting
- 2.4 Limitations

3. Instrumentation
- 3.1 Types
- 3.2 Applications
- 3.3 Limitations

4. Machinery basics
- 4.1. Machine types
- 4.2. Machine components
- 4.3. Machine orientations

5. Data collection procedures
- 5.1 Upload/download route
- 5.2 Following a route
- 5.3 Data acquisition

6. Safety and health
- 6.1 Mechanical
- 6.2 Electrical
- 6.3 Environmental
- 6.4 Regulations
- 6.5 Equipment

Level 2:

1. Review
- 1.1 Basic principles
- 1.2 Basic terminology
- 1.3 Transducers
- 1.4 Instrumentation

2. Additional terminology
- 2.1 Data acquisition
- 2.2 Signal processing
- 2.3 Data presentation

3. Diagnostic tools

3.1 Phase
3.2 FFT
3.3 Time waveform
3.4 Orbit analysis
3.5 Bode/Nyquist
3.6 Trend analysis

4. Data acquisition

4.1 Units
4.2 Analysis parameters
4.3 Alarm levels
4.4 Time constant (min/max)
4.5 Speed consideration
4.6 Lines of resolution
4.7 Overlap
4.8 Averages
4.9 Averaging and data collection methods
4.10 Windows
4.11 Sensitivity
4.12 Special transducers
4.13 Routes and online systems
4.14 Transducer selection
4.15 Transducer location
4.16 Types of data collection
4.17 Resonance testing
4.18 Instrument calibration check
4.19 Codes, standards and specifications

5. Signal processing

5.1 Windows/weighing
5.2 Overlap
5.3 Filters
5.4 Sampling rate and size
5.5 Digital vs. analog

6. Data presentation

6.1 Scope and limitations of different testing methods
6.2 Waterfall/cascades
6.3 Linear vs. logarithmic
6.4 Trends
6.5 Changing units
6.6 True zoom and expansion
6.7 Order and/or frequency

7. Problem identification

7.1 Iimbalance
7.2 Misalignment
7.3 Resonance
7.4 Bearing defects
7.5 Looseness
7.6 Bent shafts

7.7 Gear defects
7.8 Electrical defects
7.9 Hydraulic/flow dynamics
7.10 Rubs
7.11 Belts and couplings
7.12 Eccentricity

8. Reporting methodology
8.1 Technical reports
8.2 Management oriented reports
8.3 Oral reports

9. Safety and health

Level 3:

1. Principles/theory
1.1 Physical concepts
1.2 Data presentation
1.3 Sources of vibration
1.4 Correction methods

2. Equipment
2.1 Sensors
2.2 Signal condition
2.3 Instruments
2.4 On-line monitoring
2.5 Equipment response to environments

3. Techniques/calibration
3.1. Calibration
3.2. Measurement and techniques
3.3. Correction techniques

4. Analysis/evaluation
4.1 Data analysis
4.2 Data evaluation

5. Procedures
5.1 "To be able to develop procedures for performing the various types of testing techniques needed to determine equipment condition"

6. Safety and health
6.1 "Working in close proximity to operating equipment containing a great deal of energy, special care must be taken to avoid injury in addition to using specific personal protective equipment."

16. APPENDIX F - TRAINING EQUIPMENT

The following appendix includes suggested equipment requirements for training courses in main NDT methods.

SR. NO	Equipment UT	QUAN-TITY
1	Digital ultrasonic flaw detector with A-screen image and Lemo 0 socket for probes (including DGS- and DAC-correction)	3
2	Calibration Block V1	3
3	Calibration Block V2	3
4	Straight beam probe (frequency 2 MHz and diameter 24 mm)	3
5	Straight beam probe (frequency 4 MHz and diameter 10 - 13 mm)	3
6	Twin crystal straight beam probe (frequency 4 MHz and diameter 10 - 13 mm)	3
7	Angle beam probe (frequency = 4 MHz, diameter 10 - 13 mm and angle 30°)	3
8	Angle beam probe (frequency = 4 MHz, diameter 10 - 13 mm and angle 60°)	3
9	Angle beam probe (frequency = 4 MHz, diameter 10 - 13 mm and angle 45°)	3
10	Angle beam probe (frequency = 2 MHz, diameter 10 - 13 mm and angle 30°)	3
11	Angle beam probe (frequency = 2 MHz, diameter 10 - 13 mm and angle 60°)	3
12	Angle beam probe (frequency = 2 MHz, diameter 10 - 13 mm and angle 45°)	3
13	Straight beam probe (frequency = 1 MHz and diameter 24 mm)	3
14	High resolution straight beam probe (frequency 0,5- 4 MHz and diameter 24 mm)	4
15	Cable for miniatur probes (Lemo 00/Lemo 0) with length of 1,5 – 2 m	10
16	Cable for normal probes (Lemo 0/Lemo 0) with length of 1,5 – 2 m	5
17	Twin cable for twin crystal probes (Lemo 00/Lemo 0) with length of 1,5 – 2 m	5

Position 4 to 14 must be delivered with valid DGS diagram

SR. NO	Equipment UT	QUAN-TITY
1	AC hand yoke for MT testing with rigid legs (for 220 Volts)	3
2	Portable UV-light for 220 Volts, 100 Watt	3

3	Current generator 42 volts, 1500 A eff. including cables and prods for MT	1
4	Portable Power supply 220 V, 50 Hz, 3 KVA for field work	1
5	Tangential field strength meter with digital reading (min. range: 0 – 200 A/cm for AC and DC measurements including reference magnet for system calibration)	3
6	Calibrated portable lux meter with digital reading and battery operation (min. Range 0- 3000 lux)	3
7	Calibrated portable UV meter with analog reading for wave length 365 nm (battery operated)	3
8	Reference blocks for magnetisation, field direction, quality of fluid	4

SR. NO	Equipment PT	**QUAN-TITY**
1	Calibrated portable lux meter with digital reading and battery operation (min. Range 0- 3000 lux)	2
2	Calibrated portable UV meter with analog reading for wave length 365 nm (battery operated)	2
3	Reference block No. 2 in accordance with EN/ISO 3452-3	2
4	Ultrasonic cleaning bath for test specimens with dimensions of 300 x 300 mm	1
5	Set of penetrant testing systems for daylight and black-light	5

SR. NO	Equipment RT	**QUAN-TITY**
1	Portable X-ray tube and gamma source	1
2	Manual developing unit for radiographs	1
3	Film drying unit	1
4	Set of double wire image quality indicator in Fe and Al	1
5	Set of step-hole type image quality indicator (material: Fe)	1
6	Vacuum packaged films (for each class)	50
7	Chemicals for manual film development	1

8	Film density meter	1
9	Film viewing apparatus	2

SR. NO	Equipment VT	**QUAN-TITY**
1	Rigid videoscope with mirror tube technique for direction of view (0° and 90°) max. diameter = 20 mm, length = 500 – 600 mm including light source, light-conductor and 30 cm colour monitor	1
2	Rigid fiber optic light stick with direction of light = 0° and length ≈ 200 mm	2
3	Surface quality comparators for castings (shorter set)	1
4	Surface quality comparators for castings big set	1
5	Education kit with min. 10 samples of welds (butt- and tee-joints) with typical surface defects different types of cracks, porosity, lack of penetration and imperfect shape and dimensions (one kit for training and another for examination)	2 (one of each)
6	Different types of welding gauges according to EN 970 for butt welds and tee welds (for each weld joint)	12
7	Set of magnifying lenses (magnification: 2x, 5x, 8x, 10x)	2
8	Set of inspection mirrors with diameter ≈ 5, 10 and 20 mm and length = 200 – 300 mm	2
9	Rigid endoscope with direction of view = 0°, length = 500 – 600 mm, diameter = 8 – 10 mm including light source and light-conductor	1
10	Same as Sr. No. 9 with direction of view = 90°	1
11	Rigid endoscope with exchangeable objectives for direction of view (0° and 90°) and diameter = 8 – 10 mm, length = 500 – 600 mm including light source and light-conductor	1
12	Rigid endoscope with zoom (10x – 20x) and direction of view 90°, diameter = 8 – 10 mm, length = 500 – 600 mm including light source and light-conductor	1

SR. NO	Equipment ET for testing of non-ferrous materials	**QUAN-TITY**
1	Eddy current instruments with an impedance plane display which has a continuous frequency selection ranging from approximately 100Hz to 2 MHz	1

2	Number of surface, ID, and ring probes	1
3	Reflection ring probes for fastener holes inspection frequency range 100 Hz - 10KHz	1
4	Reflection ring probes for fastener holes inspection frequency range 250 Hz - 40KHz	1
5	Reflection ring probes for fastener holes inspection frequency range 400 Hz - 5 KHz	1
6	Set of eight conductivity standards	1
7	Test samples with fasteners, coatings, conductivity differences, cracks	10

17. APPENDIX G – INTRODUCTION TO DISTANCE TRAINING/E-LEARNING

1. General

Nowadays Nondestructive Testing is getting more and more developed. It provides a widespread automation for setup and calibration of devices, documentation and inspection procedures, scanning of object's surface and decoding of testing results. By the means of computer and the Internet it has become possible to use such a modern method as distance learning for preparing qualified specialists of Nondestructive Testing.

In the sphere of Nondestructive Testing distance learning is set to be organized directly by The Certification body or under its constant control.

2. When distance learning is necessary

Distance learning occurs when there is a separation between the instructor and the student, usually due to geographical or time concerns that prevent the student from attending an on-campus course.

3. Number of potential participants

The number of potential participants is almost unlimited.

4. Principles of distance learning:

- Humanity. Any person regardless of age, nationality, religion or state of health can use distance learning. The process of learning is not supplied with tough timetable or needless subjects. The student can choose his own learning schedule and subjects to study.
- Interactivity. A student exchanges information during distance learning as well as asks questions and communicates with teachers and other students.
- Initial knowledge. It is desirable to have preliminary training or some technical skills for making distance learning more effective.
- Individualization. Every student is provided with individual approach for distance learning. Incoming and regular tests are taken to find out the level of knowledge of students as well as the efficiency of learning and the necessity in additional classes to be taken. Good distant courses provide the opportunity for students to make up their own minds, take responsibility for their learning, create projects or focus on an element of the topic that they particularly enjoy.
- Identification. To avoid falsification of tests and individual tasks a lot of technical means are used. One of them is video conference with the student taking the test.

5. The means of distance learning usually include:

- Textbooks (hard or soft copies);
- Network teaching manuals;

- Audio and video materials;
- Distant practical laboratory works;
- Training simulators and programs based on virtual reality;
- Database of knowledge with free access;
- Electronic libraries;
- Website

6. Innovation techniques

A virtual learning environment allows students and teacher to meet online through a synchronous web-based application. The teacher is able to present lessons through video, PowerPoint, or chatting. The students are able to talk with other students and the teacher, as well as collaborate with each other, answer questions, or pose questions. They can use the tools available through the application, virtually raise their hand, send messages, or answer questions on the screen given by the teacher.

The increased availability of computer resources makes the use of simulations for distance learning a better option for development and improvement of practical knowledge of students. Programs based on virtual reality and training simulators can help students to become more familiar and comfortable with practice aspects. They let users carry out tasks that can be difficult in the real world due to constraints and restrictions, such as cost, scheduling or location. The simulation of Nondestructive Testing, for example, plays an increasing role as it provides an efficient way to conceive and to optimize methods of Nondestructive Testing or probes, helps for data interpretation, supports inspection qualifications. It allows easy variation of the testing object and inspection parameters. This way effects that influence the inspection such as surface roughness, grain scattering, misalignment and weld properties can be easily implemented.

7. Distance learning advantages:

Flexibility. Students can complete their distance course work from anywhere, provided there's a computer and Internet connection. This allows students to work when and where it is more convenient for them without having to squeeze in scheduled classes.

Wide range of choice for universities. There is a great possibility to choose the university which can offer the required programs, resources to succeed and degrees.
It allows students anywhere in the world to choose from a wide range of educational facilities.

Low costs. Prices for distant courses are generally cheaper than their on-campus counterparts and you will not have to worry about commuting, moving or getting meal plans on-campus.

Learn while working. It is much easier to complete distance learning courses while working than more traditional educational programs. Many people who are balancing jobs and family with school enjoy the freedom of being able to schedule their classes around their lives. Most online programs also allow students to work at their own pace so that they may take longer to complete assignments if they need extra time or can speed through material that is easy for them.

8. Distance learning disadvantages:

Possible limitations. Distance learning can be successfully used for theoretical preparation for methods of Nondestructive Testing. However, it is necessary to take a practical course which is impossible to be realized distantly with no training centre supplied with needed equipment and teaching specimens.

Lack of social interaction. Distant course means much individual work and only network interaction. It can be not appropriate or comfortable for students preferring traditional education that provides face-to-face communication.

Online degree restrictions. Some companies tend not to trust distance learning courses. Therefore it is necessary to get some information about distance learning course and requirements of supposed employer and suggested vacancies.

Adaptability to new technologies. It is difficult for some students to use modern technologies of distance learning due to the lack of experience and needed skills. It is necessary for a student to make sure he feels comfortable working with computer and online programs before signing up for a class.

9. Summary

All in all, it is a student's business whether to start distance learning or not, considering its advantages and disadvantages. But the fact is that distance learning still remains a good possibility to improve your knowledge, get some new information and motivations, benefit from using means of distance learning and perfect yourself. Concerning the issues of Nondestructive testing, distance learning can help to teach as well-qualified specialists as those who use traditional methods of learning.

18. BIBLIOGRAPHY

[1] ISO 9712:2012, Non-destructive testing — Qualification and certification of personnel

[2] ISO/CD/TR 25107:2006, Non-destructive testing — Guidelines for NDT training syllabuses

[3] ISO/TR 25108:2006, Non-destructive testing — Guidelines for NDT personnel training organizations

[4] ISO 20807:2004, Non-destructive testing — Qualification of personnel for limited application of non-destructive testing

[5] Radiation Protection and Safety in Industrial Radiography, Safety Report Series N0. 13 (1999), International Atomic Energy Agency

[6] ALLGAIER, M.W., NESS, S., MCINTIRE, P., Eds, Nondestructive Testing Handbook, Volume 8, second edition, Visual and Optical Testing. ASNT, Columbus, Ohio, 1993.

[7] AMERICAN SOCIETY FOR NONDESTRUCTIVE TESTING, Recommended Practice No: SNT-TC-1A (1996), Personnel Qualification and Certification in Nondestructive Testing, Columbus, Ohio, 1996.

[8] ASME Boiler and Pressure Vessel Code — Section V, American Society of Mechanical Engineers. New York, 1998.

[9] ASNT level III Study Guide — ASNT, Columbus, Ohio, 1992.

[10] Basic Metallurgy for Non-destructive Testing, revised edition. Essex, England: W.H. Houldershaw, Ltd (British Institute of Non-Destructive Testing). 1988

[11] BIRKS, A.S., GREEN, R.E., JR., MCINTIRE, P., EDS, Nondestructive Testing Handbook, Volume 7: second edition, Ultrasonic Testing. ASNT, Columbus, Ohio, 1991.

[12] BRYANT, L.E., MCINTIRE, P., Eds, Nondestructive Testing Handbook, Volume 3, second edition, Radiography and Radiation Testing. ASNT, Columbus, Ohio, 1985.

[13] CECCO V.S., VAN DRUNEN, G., SHARP, F.L., Eddy Current Testing, Columbia, MD: GP Courseware, 1987.

[14] “Choosing NDT” Applications, Costs, and Benefits of NDT in Quality Assurance. ASNT, Columbus, Ohio, 1999.

[15] HALMSHAW, R., Non-Destructive Testing: Metallurgy and Materials Science Series. London: Edward Arnold, 1987.

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Training Guidelines in Nondestructive Testing Techniques: IAEA-TECDOC-628/Rev.1, Vienna, 2008.

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Training Guidelines in Non-Destructive Testing Techniques, Training Course Series No. 3, IAEA, Vienna, 1992.

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Non-Destructive Testing: A Guidebook on Industrial Management and Quality Control Personnel, Training Course Series No. 9, IAEA, Vienna, 1999

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Ultrasonic Testing of Materials at Level 2: Training Course Series No. 10, IAEA, Vienna, 1999

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Liquid Penetrant and Magnetic Particle Testing at Level 2, Training Course Series No. 11, IAEA, Vienna, 2000

[20] INTERNATIONAL COMMITTEE FOR NONDESTRUCTIVE TESTING, Recommendation ICNT-WH-85-Rev. 01, Requirements of Technical Knowledge of NDT Personnel, Rome, October 2000.

[21] JACKSON, C.N., JR., SHERLOCK, C.N., MOORE, P.O., Eds, Nondestructive Testing Handbook, Volume 1, third edition, Leak Testing. ASNT, Columbus, Ohio, 1998.

[22] MESTER, M.L., MCINTIRE, P., Eds, Nondestructive Testing Handbook, Volume 4: second edition, Electromagnetic Testing, ASNT, Columbus, Ohio, 1986.

[23] Personnel Certification in NDT (PCN) General Document on Examination Requirements — Issue 3 — April 2000.

[24] SCHMIDT, J.T., SKEIE, K., MCINTIRE, P., Eds, Nondestructive Testing Handbook, Volume 6: second edition, Magnetic Particle Testing. ASNT, Columbus, Ohio, 1989.

[25] STANLEY, R.K., MCINTIRE, P., MOORE, P.O., Eds., Nondestructive Testing Handbook, Volume 9: second edition, Special Nondestructive Testing Methods. ASNT, Columbus, Ohio, 1991.

19. CONTRIBUTORS TO DRAFTING AND REVIEW

Azizova, E.	Navoi Mining and Metallurgical Combinat, Uzbekistan
Einav, I.	STAR.IK Consultant, Former NDT T.O. IAEA
Abd Ibrahim, N	MINT, Chairman MSNDT, Malaysia
Holstein, R.	Chairman German Society for NDT (DGZfP), Germany
Artemiev, B.	Institute of Bauman, RSNDT, Moscow
Wojas, M.	UDT, Head of Certification, Poland
Radko, V	USRINDT, ICNDT/WG1, Head of Certification, Ukraine
Conte, J	ABENDI, Chairman ICNDT membership committee, Brazil
Bellinco, C	CNEA, Argentina
Alami, R	CNESTEN, Head DAIRI, Morocco
Bensittel, A	CNESTEN, Morocco

IAEA
International Atomic Energy Agency

No. 23

ORDERING LOCALLY

In the following countries, IAEA priced publications may be purchased from the sources listed below or from major local booksellers.

Orders for unpriced publications should be made directly to the IAEA. The contact details are given at the end of this list.

AUSTRALIA
DA Information Services
648 Whitehorse Road, Mitcham, VIC 3132, AUSTRALIA
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: books@dadirect.com.au • Web site: http://www.dadirect.com.au

BELGIUM
Jean de Lannoy
Avenue du Roi 202, 1190 Brussels, BELGIUM
Telephone: +32 2 5384 308 • Fax: +32 2 5380 841
Email: jean.de.lannoy@euronet.be • Web site: http://www.jean-de-lannoy.be

CANADA
Renouf Publishing Co. Ltd.
5369 Canotek Road, Ottawa, ON K1J 9J3, CANADA
Telephone: +1 613 745 2665 • Fax: +1 643 745 7660
Email: order@renoufbooks.com • Web site: http://www.renoufbooks.com

Bernan Associates
4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

CZECH REPUBLIC
Suweco CZ, spol. S.r.o.
Klecakova 347, 180 21 Prague 9, CZECH REPUBLIC
Telephone: +420 242 459 202 • Fax: +420 242 459 203
Email: nakup@suweco.cz • Web site: http://www.suweco.cz

FINLAND
Akateeminen Kirjakauppa
PO Box 128 (Keskuskatu 1), 00101 Helsinki, FINLAND
Telephone: +358 9 121 41 • Fax: +358 9 121 4450
Email: akatilaus@akateeminen.com • Web site: http://www.akateeminen.com

FRANCE
Form-Edit
5 rue Janssen, PO Box 25, 75921 Paris CEDEX, FRANCE
Telephone: +33 1 42 01 49 49 • Fax: +33 1 42 01 90 90
Email: fabien.boucard@formedit.fr • Web site: http://www.formedit.fr

Lavoisier SAS
14 rue de Provigny, 94236 Cachan CEDEX, FRANCE
Telephone: +33 1 47 40 67 00 • Fax: +33 1 47 40 67 02
Email: livres@lavoisier.fr • Web site: http://www.lavoisier.fr

L'Appel du livre
99 rue de Charonne, 75011 Paris, FRANCE
Telephone: +33 1 43 07 50 80 • Fax: +33 1 43 07 50 80
Email: livres@appeldulivre.fr • Web site: http://www.appeldulivre.fr

GERMANY
Goethe Buchhandlung Teubig GmbH
Schweitzer Fachinformationen
Willstätterstrasse 15, 40549 Düsseldorf, GERMANY
Telephone: +49 (0) 211 49 8740 • Fax: +49 (0) 211 49 87428
Email: s.dehaan@schweitzer-online.de • Web site: http://www.goethebuch.de

HUNGARY
Librotade Ltd., Book Import
PF 126, 1656 Budapest, HUNGARY
Telephone: +36 1 257 7777 • Fax: +36 1 257 7472
Email: books@librotade.hu • Web site: http://www.librotade.hu

INDIA
Allied Publishers
1st Floor, Dubash House, 15, J.N. Heredi Marg, Ballard Estate, Mumbai 400001, INDIA
Telephone: +91 22 2261 7926/27 • Fax: +91 22 2261 7928
Email: alliedpl@vsnl.com • Web site: http://www.alliedpublishers.com

Bookwell
3/79 Nirankari, Delhi 110009, INDIA
Telephone: +91 11 2760 1283/4536
Email: bkwell@nde.vsnl.net.in • Web site: http://www.bookwellindia.com

ITALY
Libreria Scientifica "AEIOU"
Via Vincenzo Maria Coronelli 6, 20146 Milan, ITALY
Telephone: +39 02 48 95 45 52 • Fax: +39 02 48 95 45 48
Email: info@libreriaaeiou.eu • Web site: http://www.libreriaaeiou.eu

JAPAN
Maruzen Co., Ltd.
1-9-18 Kaigan, Minato-ku, Tokyo 105-0022, JAPAN
Telephone: +81 3 6367 6047 • Fax: +81 3 6367 6160
Email: journal@maruzen.co.jp • Web site: http://maruzen.co.jp

NETHERLANDS
Martinus Nijhoff International
Koraalrood 50, Postbus 1853, 2700 CZ Zoetermeer, NETHERLANDS
Telephone: +31 793 684 400 • Fax: +31 793 615 698
Email: info@nijhoff.nl • Web site: http://www.nijhoff.nl

Swets Information Services Ltd.
PO Box 26, 2300 AA Leiden
Dellaertweg 9b, 2316 WZ Leiden, NETHERLANDS
Telephone: +31 88 4679 387 • Fax: +31 88 4679 388
Email: tbeysens@nl.swets.com • Web site: http://www.swets.com

SLOVENIA
Cankarjeva Zalozba dd
Kopitarjeva 2, 1515 Ljubljana, SLOVENIA
Telephone: +386 1 432 31 44 • Fax: +386 1 230 14 35
Email: import.books@cankarjeva-z.si • Web site: http://www.mladinska.com/cankarjeva_zalozba

SPAIN
Diaz de Santos, S.A.
Librerias Bookshop • Departamento de pedidos
Calle Albasanz 2, esquina Hermanos Garcia Noblejas 21, 28037 Madrid, SPAIN
Telephone: +34 917 43 48 90 • Fax: +34 917 43 4023
Email: compras@diazdesantos.es • Web site: http://www.diazdesantos.es

UNITED KINGDOM
The Stationery Office Ltd. (TSO)
PO Box 29, Norwich, Norfolk, NR3 1PD, UNITED KINGDOM
Telephone: +44 870 600 5552
Email (orders): books.orders@tso.co.uk • (enquiries): book.enquiries@tso.co.uk • Web site: http://www.tso.co.uk

UNITED STATES OF AMERICA
Bernan Associates
4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Co. Ltd.
812 Proctor Avenue, Ogdensburg, NY 13669, USA
Telephone: +1 888 551 7470 • Fax: +1 888 551 7471
Email: orders@renoufbooks.com • Web site: http://www.renoufbooks.com

United Nations
300 East 42nd Street, IN-919J, New York, NY 1001, USA
Telephone: +1 212 963 8302 • Fax: 1 212 963 3489
Email: publications@un.org • Web site: http://www.unp.un.org

Orders for both priced and unpriced publications may be addressed directly to:

IAEA Publishing Section, Marketing and Sales Unit, International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 or 22488 • Fax: +43 1 2600 29302
Email: sales.publications@iaea.org • Web site: http://www.iaea.org/books

14-42111

International Atomic Energy Agency
Vienna
ISBN 978–92–0–109214–4
ISSN 1011–4289