

IAEA-TECDOC-628

***Training guidelines in
non-destructive
testing techniques
1991 Edition***



INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA

October 1991

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TRAINING GUIDELINES IN NON-DESTRUCTIVE TESTING TECHNIQUES
1991 EDITION
IAEA, VIENNA, 1991
IAEA-TECDOC-628
ISSN 1011-4289

Printed by the IAEA in Austria
October 1991

FOREWORD

Non-destructive testing methods (NDT), by their very nature, allow components to be fully examined for properties or flaws without interfering with their usefulness. This grouping of inspection methods has grown from a handful of primitive techniques practised by artists to a widely known discipline which is an essential part of quality control, largely as a result of the standards demanded by the nuclear and aerospace industries.

With the conclusion in 1979 of a successful Agency executed UNDP project in Argentina, whose aim was the establishment of a national non-destructive testing centre, the Agency was asked by other countries in the Latin American and Caribbean Region to evaluate the possibility of transferring this success to the whole region. In 1982, with the financial cooperation of UNFSSTD and UNIDO, a regional project was started with the principal objective of assisting the countries in the region to reinforce autonomous NDT capability through regional cooperation.

One essential component of this project has been the harmonization of training through the development and use of course syllabi by the 18 countries* now participating in the project. To this end, a Regional Working Group was formed and one of its tasks was the development of these syllabi for the more common NDT methods. This publication is a collection of the training programmes elaborated to date which have so far been followed by close to 30,000 persons in the region who have received training in NDT as a direct result of the project.

The syllabi take into account the development work done by the International Committee for Non-destructive Testing and many national training programmes, and are meant to be an objective guide to assist in the formation of NDT personnel. They have been accepted for use in the Asia and Pacific Region** and are referenced as the training guidelines in the Standard for the Qualification and Certification of NDT Personnel by the International Organization for Standardization (ISO).

* Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Guyana, Jamaica, Mexico, Paraguay, Peru, Trinidad and Tobago, Uruguay and Venezuela.

** Bangladesh, China, India, Indonesia, Republic of Korea, Malaysia, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam.

Recognizing the need for an international publication of NDT training syllabi, the Agency Consultants Meeting on "Qualification and Certification of NDT personnel" (Milan, 20-21 May 1986), recommended that the Agency publish the guidelines developed by Regional Working Group of the Latin America and Caribbean project. It was first issued in English in 1987 and has now been re-edited in English and Spanish and enlarged by the addition of programmes for other techniques.

The Agency wishes to express its appreciation to all those who have contributed to the compilation of this collection of course syllabi, and to the governments and organizations whose financial and technical support have made this publication possible.

EDITORIAL NOTE

In preparing this material for the press, staff of the International Atomic Energy Agency have mounted and paginated the original manuscripts and given some attention to presentation.

The views expressed do not necessarily reflect those of the governments of the Member States or organizations under whose auspices the manuscripts were produced.

The use in this book 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.

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I. RADIOGRAPHIC TESTING (RT)

INSPECTION METHOD: RADIOGRAPHIC INSPECTION

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	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	8	16
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SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Non-destructive testing of materials
 - 1.1.1 Definitions
 - 1.1.2 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 testing
 - d) Radiographic testing
 - e) Ultrasonic testing
 - f) Eddy current testing
 - g) Leak testing
 - 1.1.4 Limitations in the application of radiographic testing
- 1.2 Materials
 - 1.2.1 Properties of materials (metallic and non-metallic)
 - 1.2.2 Properties of metals
 - 1.2.3 Discontinuities
 - 1.2.4 Defects

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) define the nature of a 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.3 Processes and defects
 - 1.3.1 Primary processes and related defects
 - a) Melting
 - b) Pouring
 - c) Cooling
 - 1.3.2 Processing and related defects
 - a) Casting
 - b) Welding
 - c) Forging
 - d) Rolling
 - e) Heat treatment
 - f) Machining
 - g) Plating
 - h) Other processes
 - 1.3.3 Service and related defects
 - a) Overload
 - b) Fatigue
 - c) Corrosion
 - d) Brittle fracture
 - e) Others

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to:
 - a) list the various metallurgical processes of fabrication and bonding;
 - b) describe the possible defects associated with each type of process;
 - c) describe the possible defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Course notes
Samples of materials with typical defects

SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

- 2.1 Penetrating radiation
 - 2.1.1 X-rays and gamma-rays
 - 2.1.2 Wavelength and energy
 - 2.1.3 X-ray and gamma-ray spectra
 - 2.1.4 KVp - KVc - KeV, MeV
 - 2.1.5 Inverse square law for distance/intensity
 - 2.1.6 General properties of propagation of penetrating radiation
 - 2.1.7 Units related to penetrating radiation
- 2.2 Principles of radioactive decay
 - 2.2.1 Radioactivity
 - 2.2.2 Half-life
 - 2.2.3 Artificial and natural sources

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 sources.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
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 Absorption, dispersion, photoelectric effect, Compton effect, pair production

2.3.2 Absorption coefficient, half-thickness

2.4 Detection of ionizing radiation

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-thicknesses.

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 radiation magnitudes;
- c) distinguish between types of radiation measurement instruments, describing their proper application.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials
Calculator

SUBJECT: 3. EQUIPMENT - RADIATION SOURCES

CONTENTS:

3.1 X-ray equipment

- 3.1.1 X-ray generators and tubes, target material and characteristics, configuration, focus, heat dissipation
- 3.1.2 Head, control cabinet, power source
- 3.1.3 Accessories

3.2 Gamma ray source

- 3.2.1 Types, spectrum, activity, shielding, collimators
- 3.2.2 Handling

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:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials
X-ray equipment
Radiological protection equipment (a radiation monitor and dosimeter as a minimum)
Gamma ray source

SUBJECT: 4. PHOTOGRAPHIC AND NON-PHOTOGRAPHIC RECORDING

CONTENTS:

- 4.1 Photographic recording (X-ray and gamma ray)
 - 4.1.1 Film, principles, properties
 - 4.1.2 Emulsions, classes, characteristic curves, radiographic quality
 - 4.1.3 Lead and fluorescent screens
 - 4.1.4 Types of film for industrial radiography
- 4.2 Description of the fluoroscopic test

SPECIFIC OBJECTIVES:

- 4.1 Given the instructor's explanations, the student will 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:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials
Manual for various brands of film
Screens

SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

- 5.1 Parameters and work conditions
 - 5.1.1 Image density, factors affecting it
 - 5.1.2 Geometric principles, penumbra
 - 5.1.3 Image quality, contrast and definition
 - 5.1.4 Disperse radiation, causes, control
 - 5.1.5 Use of screens, masks, filters
 - 5.1.6 Exposure curves, X-rays, gamma rays, exposure calculations
 - 5.1.7 Image quality indicators, procedure
-

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 disperse 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:

Blackboard
Transparencies
Slides
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
Accessories

CONTENTS:

- 5.2 Care in the handling and conservation of film
 - 5.2.1 Darkroom: equipment, chemicals, processing of the film
- 5.3 Viewing of radiographs
 - 5.3.1 General background, lighting, viewers
- 5.4 Evaluation of radiograph quality:
 - 5.4.1 Causes and corrections of defective radiographs
 - 5.4.2 Processing defects, high density, low density, contrast, definition, fog
 - 5.4.3 Image quality indicators
 - 5.4.4 Identification
 - 5.4.5 Density measures

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
Blackboard
Sample defective radiographs

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 Given the instructor's explanations, the student will be able to compare image size and object, explaining the variables which affect this relationship.
- 6.2 Given the instructor's explanations and radiographs of different work pieces, the student will be able to:
 - a) recognize defect indications typical of welds and cast pieces;
 - b) relate the type of discontinuity to its radiographic image.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Standard radiographs
Viewer

CONTENTS:

- 7.1 Influence of the 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 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:

Blackboard
Work pieces of various materials, codes
Work pieces of different standards geometry
Radiographic equipment

INSPECTION METHOD: RADIOGRAPHIC TESTING

LEVEL: 1

SUBJECT: 8. SELECTION OF TEST METHODS ACCORDING TO STANDARDS, ETC.

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
- 8.2 Performance of tests in accordance with written instructions

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.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including lecture, delivery of support material, guided discussion and practical application of written instructions.

EQUIPMENT AND RESOURCES:

Blackboard
Code, standards (ASME, ASTM, DIN, API, BTS, COVENIN, JIS)
Test procedures
Work pieces, radiographic equipment and accessories

INSPECTION METHOD: RADIOGRAPHIC TESTING

LEVEL: 1

SUBJECT: 8. SELECTION OF TEST METHODS ACCORDING TO STANDARDS, ETC.

CONTENTS:

8.3 Identification of radiographs and recording of tests

SPECIFIC OBJECTIVES:

8.3 Given the instructor's explanations and various practical examples of performing radiography 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 workshop (filling out the form).

EQUIPMENT AND RESOURCES:

Blackboard
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:

9.1 Dangers of excessive exposure to X-rays and gamma rays

9.1.1 Somatic and genetic effects

9.2 Maximum permissible doses

9.3 Method of controlling exposure dose: time, distance, shielding

9.4 Units

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:

Blackboard
Transparencies
Calculator
Dosimeters and monitors

INSPECTION METHOD: RADIOGRAPHIC TESTING

LEVEL: 1

SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION

CONTENTS:

9.5 Specific requirements of safety for operation of X-ray and gamma ray equipment

- 9.5.1 Monitoring, recording
- 9.5.2 Shielding for exposure, bunkers
- 9.5.3 Operation, warning systems

9.6 Operational and emergency procedures

SPECIFIC OBJECTIVES:

- 9.5 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.
- 9.6 Given the instructor's explanations and examples of emergency situations and procedures, 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:

Blackboard
X-ray and gamma ray equipment, monitors, dosimeters
Bunker warning system
Collimators

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Basic principles of NDT
 - 1.1.1 Definitions and methodology of applications of basic methods
 - 1.1.2 Fields of application of common methods
 - 1.1.3 Range and limitations of common methods
 - 1.1.4 Limitations in the application of radiographic testing
- 1.2 Materials and defects
 - 1.2.1 Structure of metals and alloys
 - 1.2.2 Properties of materials (metallic and non-metallic)
 - 1.2.3 Discontinuities and defects in metallic materials

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 material;
 - b) describe the various types of discontinuities and defects, their sources and their classification.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

- Transparencies
- Slides
- Films
- Blackboard
- Course notes

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
- 1.4 Materials in service
 - 1.4.1 Behaviour of materials in service
 - 1.4.2 Service conditions leading to defects and failures:
 - a) Corrosion
 - b) Fatigue
 - c) Wear
 - d) Overload
 - e) Brittle fracture
 - 1.4.3 Concepts of rupture development in metals

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 the basic mechanisms giving rise to defects when the component is in service;
 - b) describe the defects that could arise during service and the general significance of each.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Samples of materials and defects

INSPECTION METHOD: RADIOGRAPHIC TESTING

LEVEL: 2

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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:

- 1.5 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, guided discussion and review of examples.

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Typical documents, i.e. codes

SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

- 2.1 The nature of penetrating radiation
 - 2.1.1 Corpuscular and electromagnetic radiation
 - 2.1.2 X-rays and gamma rays
 - 2.1.3 Wavelength and energy
 - 2.1.4 X-ray and gamma-ray spectra
 - 2.1.5 Inverse square law for distance/intensity
 - 2.1.6 General properties of the propagation of penetrating radiation
 - 2.1.7 Units related to penetrating radiation
- 2.2 The elements of radioactive decay, radioactivity/half life/natural and artificial sources
 - 2.2.1 Measurement of intensity and concept of specific emission (R/Ci-h at 1 m, Gy/Bq-h at 1 m)
- 2.3 Alpha and beta particles, neutrons

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 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies

SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.4 Interaction of radiation with matter

- 2.4.1 Absorption, dispersion, photoelectric effect, Compton effect, pair production
- 2.4.2 Absorption coefficient
- 2.4.3 Half-value thickness
- 2.4.4 Use of tables for calculating attenuation of gamma and X-radiations

2.5 Measurement of ionization and units

- 2.5.1 Detection of radiation by ionization
- 2.5.2 Exposure, absorbed dose, equivalent dose
- 2.5.3 Dose intensity

2.6 Principles of X and gamma ray detection

- 2.6.1 Film, fluorescent material, electronics
- 2.6.2 Accuracy of measurements
- 2.6.3 Limits of application

SPECIFIC OBJECTIVES:

- 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:

Blackboard
Transparencies

SUBJECT: 3. EQUIPMENT - RADIATION SOURCES

CONTENTS:

3.1 X-Ray equipment

- 3.1.1 Generators and X-ray tubes, material and target characteristics, configuration, focus, heat dissipation
- 3.1.2 Head, control cabin, power source
- 3.1.3 Auxiliaries
- 3.1.4 Equipment design, emission, work cycle
- 3.1.5 Determination of focus length
- 3.1.6 Linear accelerators betatrons

3.2 Gamma-ray sources

- 3.2.1 Radioisotopes used in gamma radiography, energy, spectra, half-life, emission factors, range
- 3.2.2 Different types of gamma cameras, shielding, collimators, handling

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:

Transparencies
X-ray equipment
Radiation protection equipment (Radiation monitor and dosimeter as a minimum)
Gamma-ray source

SUBJECT: 4. PHOTOGRAPHIC AND NON-PHOTOGRAPHIC RECORDING

CONTENTS:

- 4.1 Photographic recording (Gamma-ray, X-ray)
 - 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 Lead and fluorescent screens
 - 4.1.4 Types of film for industrial radiography
 - 4.1.5 Use of sensitometric curves
 - 4.1.6 Exposure curves
 - 4.1.7 Brightness and penumbra responses of fluorescent screens
- 4.2 Description of fluoroscopy test
 - 4.2.1 Image intensifiers
 - 4.2.2 Image and intensifiers
 - 4.2.3 TV systems
 - 4.2.4 Xerox radiography

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.;
 - b) explain the differences between fluoroscopy and conventional radiography.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Manuals for different makes of film
Sensitometric curves
Screens

CONTENTS:

- 5.1 Parameters and working conditions
 - 5.1.1 Image density, factors which affect it
 - 5.1.2 Geometrical principles, penumbra
 - 5.1.3 Image quality, contrast and definition
 - 5.1.4 Disperse radiation cause control
 - 5.1.5 Use of screens, masks, filters
 - 5.1.6 Exposure curves, X-rays, gamma rays, exposure calculations
 - 5.1.7 Image quality indicators, positioning
 - 5.1.8 Interpretation of test instructions
 - 5.1.9 Choice of films
 - 5.1.10 Preparation of exposure curves
 - 5.1.11 Choice of screens
 - 5.1.12 Magnification and distortion of the projected image
 - 5.1.13 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 the various geometrical factors with respect to definition of the radiographic image;
 - c) use screens, collimators and filters in checking disperse 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:

Blackboard
Test procedures
Various types of quality indicators
Sample work pieces
Screens, filters and masks
Meter
Exposure curves
Calculator
Densitometer
Density samples
X-ray equipment
Accessories
Slides

SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

5.2 Film processing

- 5.2.1 Principle of image formation
- 5.2.2 Processing in darkroom
- 5.2.3 Equipment and reagents
- 5.2.4 Care to be taken in handling and conserving the film
- 5.2.5 Safety lamps
- 5.2.6 Checking on the use of reagents, temperatures, processing time
- 5.2.7 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

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Radiographic film
Darkroom
Processing equipment
Drawing equipment
Viewer
Reference radiographs

SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

- 5.4 Evaluation of radiographic quality
 - 5.4.1 Causes and correction of defective radiographs
 - 5.4.2 Processing defects, high density, low density, contrast, definition, fog
 - 5.4.3 Image quality indicators
 - 5.4.4 Identification
 - 5.4.5 Density measurement
 - 5.4.6 Systematic control of radiographic quality

SPECIFIC OBJECTIVES:

- 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 and practical exercises on viewing of defective radiographs.

EQUIPMENT AND RESOURCES:

Blackboard
Sample radiographs
Viewer
Densitometers
Slides

SUBJECT: 6. DEFECTOLOGY

CONTENTS:

- 6.1 Basic factors
 - 6.1.1 Relation between image and object
- 6.2 General information on the nature of discontinuities in radiography
- 6.3 Interpretation of radiographic images
 - 6.3.1 Use of reference radiographs (welding, casting, corrosion, etc.).

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:

Blackboard
Standard radiographs
Sample radiographs
Viewer
Densitometers
Standards
Slides

SUBJECT: 7. SELECTION OF TECHNIQUES

CONTENTS:

7.1 Influence of the properties of the material

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 Thickness compensation

7.2.6 Masks

7.3. Detection probability depending on type, size, position and orientation of the defect

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:

Blackboard

Work pieces of various materials (steel, aluminum, etc.)

Codes

Work pieces of different geometry

Standards

Transparencies

Slides

SUBJECT: 8. SELECTION OF TEST METHODS, ACCORDING TO STANDARDS, ETC.

CONTENTS:

- 8.1 General knowledge of codes and standards
 - 8.1.1 General knowledge of specification and procedures
 - 8.1.2 Interpretation of procedures and compilation of test instructions
- 8.2 Performance of test in accordance with written instructions
 - 8.2.1 Records of operating conditions on test forms
 - 8.2.2 Evaluation of tasks carried out by Level 1 operators
- 8.3 Instructions for testing in special situations
 - 8.3.1 Range of application of the test, equipment and technique

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 exercise on interpretation of procedures and compilation of instructions.

EQUIPMENT AND RESOURCES:

Blackboard
Codes
Standards (ASME, ASTM, DIN, API, BSI, COVENIN, JIS)
Test procedures and examples of instructions
Work pieces (steel, aluminum, etc.)
Equipment and accessories
Radiographs
Slides

SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION

CONTENTS:

- 9.1 Dangers of excessive exposure to X-rays and gamma-rays
 - 9.1.1 Somatic and genetic effects
- 9.2 Maximum permissible doses
- 9.3 Method of monitoring exposure dose, time, distance, shielding
- 9.4 Specific safety requirements for the operation of X-ray and gamma Ray equipment
 - 9.4.1 Monitoring, recording
 - 9.4.2 Shielding or exposure, bunkers
 - 9.4.3 Operation of warning systems
 - 9.4.4 Calculation of shielding and distances
- 9.5 Operational and emergency procedures
 - 9.5.1 Accident report

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Calculator
X-ray and gamma-ray equipment
Monitors
Dosimeters
Bunkers, warning system

SUBJECT: 10. SPECIAL APPLICATIONS

CONTENTS:

- 10.1 Multiple film techniques
- 10.2 Projection and magnification techniques
- 10.3 Panoramic exposure
- 10.4 Determination of depth of defects
- 10.5 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)

SPECIFIC OBJECTIVES:

- 10.1 Given the instructor's explanations, the student will be able to use multiple film techniques.
- 10.2 Given the instructor's explanation, the student will be able to explain techniques of projection and magnification in radiography.
- 10.3 Given the instructor's explanations, the student will be able to describe panoramic exposure techniques.
- 10.4 Given the instructor's explanations, the student will be able to measure the depth of defects.
- 10.5 Given the instructor's explanations, the student will be able to describe radiography of non-metallic materials.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Course notes
Blackboard
Transparencies
Examples
Slides

SUBJECT: 11. RECORDING AND INTERPRETATION OF RESULTS

CONTENTS:

- 11.1 The recording of tests
 - 11.1.1 Test documentation
- 11.2 Evaluation of results according to standards and application of codes

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:

Blackboard
Transparencies
Slides
Example radiographs

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Technology of NDT

- 1.1.1 Definitions and methodology of applying NDT. Specific and distinctive characteristics of these methods.
- 1.1.2 Areas of NDT application. Quality control, maintenance. Defectology. Evaluation of properties.
- 1.1.3 Physical properties of the usual methods and their correlations with the examination requirements and defectology. Scope and limitations. Comparison of the most common methods.

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) discuss the methodology of applying NDT as well as the specific and distinctive characteristics of these methods;
 - b) determine the conditions for using NDT, evaluating its importance relative to the various types of problems and areas of application;
 - c) discuss the scope and the limitations of the various methods, correlating the physical principles with the test requirements, the defectology and the type of materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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 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 Plastic flow
- 1.2.10 Millwork, forging and power metallurgy
- 1.2.11 Machining fundamentals
- 1.2.12 Miscellaneous processes
- 1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

- 1.2 Given the instructor's explanations, the student will be able to:
- a) describe, interpret, analyze and evaluate the defectology 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 bondings;
 - d) recognize various types of compound materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 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

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

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
 - 2.1.3 Wavelength and energy
 - 2.1.4 X-ray and gamma-ray spectra
- 2.2 Radioactive decay
 - 2.2.1 Radioactivity, half-life
 - 2.2.2 Artificial and natural sources
 - 2.2.3 Alpha and beta particles, neutrons, gamma radiation
 - 2.2.4 Measurement of intensity: concept of specific emissions (R/Ci.h at 1 m, Gy.Bq.h at 1 m)
- 2.3 Interaction of radiation with matter
 - 2.3.1 Absorption, scattering. Photoelectric effect, Compton effect, pair production
 - 2.3.2 Absorption coefficient
 - 2.3.3 Half-thickness
 - 2.3.4 Calculation of attenuation coefficient for simple materials and compounds
 - 2.3.5 Radiographic equivalents
- 2.4 Measurement of ionization and units
 - 2.4.1 Detection of radiation by ionization
 - 2.4.2 Exposure, absorbed dose, equivalent dose, dose intensity
 - 2.4.3 Calculations relating to radiation dosimetry
- 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 the various mechanisms of 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 the various detection systems.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard. Transparencies. Slides. Chart of radionuclides and radioactive decay.

SUBJECT: 3. EQUIPMENT - RADIATION SOURCES

CONTENTS:

- 3.1 Industrial radiation sources
 - 3.1.1 X-ray generators, linear accelerators, betatrons
 - 3.1.2 Equipment for gamma radiation and neutron generators
 - 3.1.3 Purchase, acceptance, operation and maintenance
 - 3.1.4 Shielding, filtering and collimation
- 3.2 Facilities for industrial radiography
- 3.3 Accessories

SPECIFIC OBJECTIVES:

- 3. Given the instructor's explanations, the student will be able to:
 - a) explain the principles of designing equipment and accessories;
 - b) design facilities for industrial radiography;
 - c) design collimators;
 - d) design and evaluate radiographic viewers and lighting systems.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
X-ray equipment
Radiation protection equipment (one radiation monitor and one dosimeter as a minimum)

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 film for industrial radiography
 - 4.1.4 Sensitometric curves
 - 4.1.5 Exposure curves
 - 4.1.6 Lead and fluorescent screens
- 4.2 Radiography in real time
 - 4.2.1 Testing by fluoroscopy
 - 4.2.2 Image intensities for image transmission by TV
- 4.3 Xeroradiography

SPECIFIC OBJECTIVES:

- 4.1 Given the instructor's explanations, the student will be able to:
 - a) evaluate structural characteristics of radiographic film;
 - 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Blackboard
Manuals for different makes of films
Sensitometric curves
Screens

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 radiography
 - 5.2.1 Testing sensitivity. Fluctuation and resolution
- 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 thereof
 - 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
Standardized reference radiographs
Slides

SUBJECT: 6. DEFECTOLOGY

CONTENTS:

- 6.1 Radiographic indication of defects
 - 6.1.1 Relation between image and object
 - 6.1.2 Types of defects and their formation
 - 6.1.3 Casting, welding, heat treatments, forging, lamination, corrosion, etc.
- 6.2 Discontinuities in radiography
 - 6.2.1 Standard reference radiographs (IIW, ASTM, etc.)

SPECIFIC OBJECTIVES:

- 6.1 Given the instructor's explanations, the student will 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:

Blackboard
Transparencies
Standard radiographs
Viewers
Densitometers
Slides

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 according to type, size, position and direction 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:

Blackboard

Work pieces of various materials and geometries (steel, aluminum, etc.)

Transparencies

Slides

INSPECTION METHOD: RADIOGRAPHIC TESTING

LEVEL: 3

SUBJECT: 8. SELECTION OF TEST METHODS ACCORDING TO STANDARDS, ETC.

CONTENTS:

- 8.1 National and international codes and standards for radiographic testing
- 8.2 Specifications for radiographic testing

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
National and international codes and standards
Typical specifications

SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION

CONTENTS:

- 9.1 Radiation and its effects
 - 9.1.1 Biological effects of radiation
 - 9.1.2 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 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

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:

Transparencies
Slides
Blackboard
Typical documents
Course notes
International regulations and recommendations
Installation plans
Comparative tables
Monitors
Dosimeters

CONTENTS:

- 10.1 Special film techniques
 - 10.1.1 Multiple film, projection and enlargement
 - 10.1.2 Panoramic exposure
 - 10.1.3 Defect-depth determination techniques
- 10.2 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)
- 10.3 Application of radiographic techniques in non-conventional areas
 - 10.3.1 Aeronautics and aerospace
 - 10.3.2 Offshore structures
 - 10.3.3 Others

SPECIFIC OBJECTIVES:

- 10.1 Given the instructor's explanations, the student will be able to develop procedures to apply special film techniques.
- 10.2 Given the instructor's explanations, the student will be able to develop and evaluate procedures for testing non-metallic materials.
- 10.3 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:

Blackboard
Slides
Test pieces
Demonstration radiographs

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:

Blackboard
Transparencies
Slides
Various types of imaging equipment
Sample test reports and radiographs

SUBJECT: 12. QUALITY ASSURANCE AND STANDARDIZATION

CONTENTS:

- 12.1 Quality assurance
 - 12.1.1 Basic principles for the application of quality assurance
 - 12.1.2 Organization of quality assurance. Quality manual. Quality control. Auditing of quality.
 - 12.1.3 Management and control of quality assurance documentation, quality control of testing
 - 12.1.4 Reports on testing, documentation systems
- 12.2 Standardization
 - 12.2.1 Definition of standardization, principles of standards writing
 - 12.2.2 Standards, codes, specifications and procedures, their uses
 - 12.2.3 Reports and protocols

SPECIFIC OBJECTIVES:

- 12.1 Given the instructor's explanations, the student will be able to:
 - a) interpret and apply quality assurance procedures to the conducting 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.
- 12.2 Given the instructor's explanations, the student will be able to:
 - a) define standardization and discuss basic principles of standards writing;
 - b) discuss the benefit and applications of standards, codes, specifications and procedures;
 - c) write reports and keep records which meet the requirements of codes and standards.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Films
Course notes
Quality assurance manuals
Typical documents

SUBJECT: 13. ORGANIZATION AND ADMINISTRATION OF NDT

CONTENTS:

13.1 Organization and administration of NDT

13.1.1 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

13.1.2 Organization

- a) Equipment for work under way. Logistic provisions
- b) Testing on production lines. Flow of materials. Work shifts
- c) Maintenance of equipment and facilities

13.1.3 Costs

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

13.1.4 Equipment selection and facility design

13.1.5 Operating procedures and record-keeping

SPECIFIC OBJECTIVES:

13.1 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:

Blackboard
Transparencies
Course notes
Sample specifications and quotations
Sample procedures

SUBJECT: 14. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL

CONTENTS:

- 14.1 Qualification and Certification of NDT personnel
 - 14.1.1 National standards for the qualification and certification of personnel. Regional and international recommendations.
 - 14.1.2 Training of NDT personnel. Organization of courses and training in NDT methods.
 - 14.1.3 Code of ethics

SPECIFIC OBJECTIVES:

- 14.1 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:

Blackboard
Transparencies
Slides
Applicable standards and documents
Course notes

II. ULTRASONIC TESTING (UT)

INSPECTION METHOD: ULTRASONIC TESTING

S U B J E C T	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	8	16
2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS	8	8	8
3. TESTING TECHNIQUES AND THEIR LIMITATIONS	4	8	4
4. EQUIPMENT AND ACCESSORIES	4	6	6
5. CALIBRATION OF THE TESTING SYSTEM	8	12	6
6. SPECIFIC APPLICATIONS	4	12	6
7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	4	10	10
8. RECORDING AND EVALUATION OF RESULTS	4	10	2
9. SPECIAL TECHNIQUES	-	6	6
10. QUALITY ASSURANCE AND STANDARDIZATION	-	-	6
11. ORGANIZATION AND ADMINISTRATION OF NDT	-	-	8
12. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL	-	-	2
T O T A L	40	80	80

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Non-destructive testing of materials
 - 1.1.1 Definitions
 - 1.1.2 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 testing
 - d) Radiographic testing
 - e) Ultrasonic testing
 - f) Eddy current testing
 - g) Leak testing
 - 1.1.4 Limitations in the application of ultrasonic testing
- 1.2 Materials
 - 1.2.1 Properties of materials (metallic and non-metallic)
 - 1.2.2 Properties of metals
 - 1.2.3 Discontinuities
 - 1.2.4 Defects

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) define the nature of a 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.3 Processes and defects
 - 1.3.1 Primary processes and related defects
 - a) Melting
 - b) Pouring
 - c) Cooling
 - 1.3.2 Processing and related defects
 - a) Casting
 - b) Welding
 - c) Forging
 - d) Rolling
 - e) Heat treatment
 - f) Machining
 - g) Plating
 - h) Other processes
 - 1.3.3 Service and related defects
 - a) Overload
 - b) Fatigue
 - c) Corrosion
 - d) Brittle fracture
 - e) Others

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to:
 - a) list the various metallurgical processes of fabrication and bonding;
 - b) describe the possible defects associated with each type of process;
 - c) describe the possible defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Course notes
Samples of materials with typical defects

CONTENTS:

- 2.1 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 of conversion
 - 2.5.2 Attenuation

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, length 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 forms of attenuation.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and exercise workshop.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides

SUBJECT: 2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS

CONTENTS:

- 2.6 Energy transfer from one medium to another
 - 2.6.1 Generation of ultrasonic waves
 - 2.6.2 Energy losses in different media
 - 2.7 Piezoelectric effect, characteristics and types of crystals
 - 2.8 Sonic field: influence of speed of sound and transducer size
 - 2.9 Types of sensors:
 - 2.9.1 Normal
 - 2.9.2 Emitter-receiver
 - 2.9.3 Angular
 - 2.10 The sonic path
 - 2.10.1 Near field
 - 2.10.2 Far field
 - 2.10.3 Field divergence
-

SPECIFIC OBJECTIVES:

- 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 used in ultrasonics.
 - 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 sensor, the student will be able to:
 - a) recognize its type and structural characteristics;
 - b) compare it with the other types of sensors, 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 sonograms for different sensors.
-

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard, transparencies and slides. Various types of sensors and calculators.

SUBJECT: 3. TESTING TECHNIQUES AND THEIR LIMITATIONS

CONTENTS:

- 3.1 Pulse-echo technique:
 - 3.1.1 By direct contact
 - 3.1.2 By immersion
 - 3.1.3 With emitter-collector sensors
- 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 will 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.
- 3.5 Given the instructor's explanations, the student will be able to:
 - a) list the characteristics of an automatic testing system;
 - b) list the conditions under which an automatic testing system can be used.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides

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 Analog and digital equipment for thickness measurements
- 4.3 Monitors
 - 4.3.1 Functions
 - 4.3.2 Use

SPECIFIC OBJECTIVES:

- 4.1 Given the instructor's explanations and a set of ultrasonic (A scan) equipment, the student will be able to recognize each of the controls and describe the specific function of it.
- 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:

Blackboard
Transparencies
Slides
Ultrasonic equipment with analogue and digital displays
Sensors

SUBJECT: 5. CALIBRATION OF THE TESTING SYSTEM

CONTENTS:

- 5.1 Distance calibration for normal single and double crystal sensors (emitter-receiver)
 - 5.2 Angular sensors of transverse waves:
 - 5.2.1 Sonic path calibration
 - 5.2.2 Projected distance
 - 5.2.3 Shortened projected distance
 - 5.3 Checking the calibration: consideration of differences in speed of propagation between calibration unit and test piece
-

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 surface state ultrasonic propagation between the calibration unit and the test piece.
-

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
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)
Sample work pieces

CONTENTS:

- 6.1 Testing 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 Geometry
 - 6.2.3 Influence of surface condition
- 6.3 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 will 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:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials
Calculator
Ultrasonic equipment
Accessories
Test pieces

INSPECTION METHOD: ULTRASONIC TESTING

LEVEL: 1

SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

7.1 General knowledge:

7.1.1 Codes and standards

7.1.2 Specifications and procedures

7.2 Performance of tests in accordance with written instructions

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard

Codes and standards (ASME, ASTM, DIN, API, COVENIN, JIS, BSI, IRAM)

Ultrasonic equipment and accessories

Test pieces of simple geometry

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 Defect dimensions (average value, length)

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

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Basic principles of NDT
 - 1.1.1 Definitions and methodology of applications of basic methods
 - 1.1.2 Fields of application of common methods
 - 1.1.3 Range and limitations of common methods
 - 1.1.4 Limitations in the application of ultrasonic testing
- 1.2 Materials and defects
 - 1.2.1 Structure of metals and alloys
 - 1.2.2 Properties of materials (metallic and non-metallic)
 - 1.2.3 Discontinuities and defects in metallic materials

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 material;
 - b) describe the various types of discontinuities and defects, their sources and their classification.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Blackboard
Course notes

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
- 1.4 Materials in service
 - 1.4.1 Behaviour of materials in service
 - 1.4.2 Service conditions leading to defects and failures:
 - a) Corrosion
 - b) Fatigue
 - c) Wear
 - d) Overload
 - e) Brittle fracture
 - 1.4.3 Concepts of rupture development in metals

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 the basic mechanisms giving rise to defects when the component is in service;
 - b) describe the defects that could arise during service and the general significance of each.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Samples of materials and defects

INSPECTION METHOD: ULTRASONIC TESTING

LEVEL: 2

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 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:

- 1.5 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, guided discussion and review of examples.

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Typical documents, i.e. codes

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 Lamb wave

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Course notes
Blackboard
Transparencies
Slides

SUBJECT: 2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS

CONTENTS:

- 2.4 Behaviour of ultrasonic waves
 - 2.4.1 Normal incidence
 - 2.4.2 Angular incidence
 - 2.4.3 Reflection and refraction
 - 2.4.4 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 magnetostrictive 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
 - 2.8.1 Cause and effect
 - 2.8.2 Principles of measurement
-

SPECIFIC OBJECTIVES:

- 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 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, guided discussion and problem solving.

EQUIPMENT AND RESOURCES:

Blackboard. Transparencies. Slides. Ultrasonic instrument. Various transducers. Calibration blocks.

SUBJECT: 3. TESTING TECHNIQUES AND THEIR LIMITATIONS

CONTENTS:

- 3.1 Test 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
- 3.2 Sensors
 - 3.2.1 Normal incidence sensors
 - 3.2.2 Angular incidence sensors
 - 3.2.3 Special sensors
- 3.3 Techniques
 - 3.3.1 Tandem techniques
 - 3.3.2 Focussed sensor technique
 - 3.3.3 Double-crystal sensor technique
 - 3.3.4 Surface-wave sensor technique
 - 3.3.5 Immersion techniques
- 3.4 Limitations in the application of the ultrasonic test method.

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 will 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 will 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:

Blackboard
Transparencies
Slides
Specimen sensors

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
 - 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
 - 4.3.1 Echo amplitude and its control
 - 4.3.2 A-scan
 - 4.3.3 B-scan
 - 4.3.4 C-scan
 - 4.3.5 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 colour 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. Transparencies. Slides. Blackboard.

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 V1 and V2
 - 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 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 the various types of coupling media.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Sample written procedures
Calibration blocks
Coupling materials
Equipment
Sample DGS curves

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.)

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, angle and scanning angle;
 - b) describe the possible types of discontinuities in each case.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Demonstration work pieces
Ultrasonic equipment and materials

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 of equipment
- 7.2.2 Position and direction of scan
- 7.2.3 Calibration

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, guided discussion and discussion of case histories.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Typical codes, standards, specifications and procedures

CONTENTS:

- 8.1 Response of the equipment of various types of defect
- 8.2 Evaluation of discontinuities in accordance with specifications, standards and codes
- 8.3 Recording and reporting the results of a test

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 workpiece, 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 workpiece, 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:

Blackboard
Transparencies
Slides
Ultrasonic equipment
Test pieces
Procedures
Report forms
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

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:

Blackboard
Transparencies
Slides
Film
Samples

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Technology of NDT

- 1.1.1 Definitions and methodology of applying NDT. Specific and distinctive characteristics of these methods.
- 1.1.2 Areas of NDT application. Quality control, maintenance. Defectology. Evaluation of properties.
- 1.1.3 Physical properties of the usual methods and their correlations with the examination requirements and defectology. Scope and limitations. Comparison of the most common methods.

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) discuss the methodology of applying NDT as well as the specific and distinctive characteristics of these methods;
 - b) determine the conditions for using NDT, evaluating its importance relative to the various types of problems and areas of application;
 - c) discuss the scope and the limitations of the various methods, correlating the physical principles with the test requirements, the defectology and the type of materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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 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 Plastic flow
- 1.2.10 Millwork, forging and power metallurgy
- 1.2.11 Machining fundamentals
- 1.2.12 Miscellaneous processes
- 1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

- 1.2 Given the instructor's explanations, the student will be able to:
- a) describe, interpret, analyze and evaluate the defectology 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 bondings;
 - d) recognize various types of compound materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

INSPECTION METHOD: ULTRASONIC TESTING

LEVEL: 3

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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

SPECIFIC OBJECTIVES:

1.3 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

CONTENTS:

- 2.1 Nature of ultrasonic waves
- 2.2 Characteristics of ultrasonic wave propagation. Frequency, wave length, velocity, acoustic impedance, acoustic energy, acoustic intensity, amplitude.
- 2.3 Types of ultrasonic waves and their applications:
 - Longitudinal wave
 - Transverse wave
 - Surface wave
 - Lamb wave
- 2.4 Behaviour of ultrasonic waves
 - Normal incidence
 - Angular incidence
 - Reflection and refraction
 - Methods of conversion

SPECIFIC OBJECTIVES:

- 2.1 Given the instructor's explanations, the student will 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.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides

CONTENTS:

- 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 Far field and near field, influence of the speed of sound and the size of the transducer. Divergence of the field
- 2.8 Attenuation of sound: cause, effect, principles of measurement

SPECIFIC OBJECTIVES:

- 2.5 Given the instructor's explanations, the student will be able to:
 - a) explain the energy transfer from one medium to another;
 - b) explain 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 differences between the piezoelectric effect and the magnetorestrictive effect;
 - b) describe the advantages and disadvantages of the various crystals;
- 2.7 Given the instructor's explanations, the student will be able to sketch near field and far field indicating:
 - a) the characteristics of each of the essential differences;
 - b) the mathematical relationship limiting them;
 - c) the sonic field for a transducer, with indication of the near field and the distant field;
 - d) the sonogram for different sensor.
- 2.8 Given the instructor's explanations, the student will be able to explain attenuation of sound.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides

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

3.2 Sensors:

- 3.2.1 Normal-incidence sensors
- 3.2.2 Angular-incidence sensors
- 3.2.3 Special sensors

3.3 Techniques:

- 3.3.1 Tandem technique
- 3.3.2 Focalized sensor technique
- 3.3.3 Double crystal sensor technique
- 3.3.4 Surface-wave sensor technique
- 3.3.5 Immersion techniques

3.4 Limitations to the application of ultrasonic testing

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 limitations;
 - d) determine the limits of ultrasonic testing for each type of application.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Sample transducers
Film

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
 - 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
 - 4.3.1 Echo amplitude and its control
 - 4.3.2 A-scan
 - 4.3.3 B-scan
 - 4.3.4 C-scan
 - 4.3.5 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 colour 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. Transparencies. Slides. Blackboard.

SUBJECT: 5. CALIBRATION OF THE TESTING SYSTEM

CONTENTS:

5.1 Calibration and adjustment of the equipment:

- 5.1.1 Instrumentation
- 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 Design and preparation of calibration units
- 5.2.2 Various calibration criteria (D.A.C., D.G.S., etc.) and selection of suitable reflectors
- 5.2.3 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

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:

Blackboard
Transparencies
Slides
Test equipment, sensors and calibration blocks

CONTENTS:

6.1 Methods of Examination

- 6.1.1 Cast material
- 6.1.2 Welded pieces
- 6.1.3 Components and systems
- 6.1.4 Austenitic material
- 6.1.5 Forged pieces
- 6.1.6 Non-metallic (ceramics, plastics, etc.)

SPECIFIC OBJECTIVES:

- 6.1 Given the instructor's explanations, the student will be able to develop testing procedures to locate and evaluate discontinuities for each type of material, which will include:
- a) method of performing the test;
 - b) type of sensor;
 - c) frequency;
 - d) angle;
 - e) zone of inspection;
 - f) possible types of discontinuities.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Equipment and supplies
Samples containing discontinuities

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 ultrasonics (ASTM, JIS, BS, DIN)

7.2.2 Interpretation of specification, codes and standards

7.3 Test procedures

7.3.1 Drafting of test procedures

7.3.2 General and specific procedures

SPECIFIC OBJECTIVES:

7.1. Given the instructor's explanations and the results of practical exercises, the student will 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:

Blackboard

Transparencies

Slides

Examples of design specifications

Applicable codes and standards

Examples of general and specific procedures

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 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 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:

Blackboard
Transparencies
Slides
Equipment
Test pieces
Codes
Procedures

SUBJECT: 9. SPECIAL TECHNIQUES

CONTENTS:

- 9.1 Special techniques
 - 9.1.1 Ultrasonic holography
 - 9.1.2 Ultrasonic spectroscopy
 - 9.1.3 Automated and semi-automated testing techniques
 - 9.1.4 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:

Blackboard
Slides
Transparencies
Equipment and test samples

SUBJECT: 10. QUALITY ASSURANCE AND STANDARDIZATION

CONTENTS:

- 10.1 Quality assurance
 - 10.1.1 Basic principles for the application of quality assurance.
 - 10.1.2 Organization of quality assurance. Quality manual. Quality control. Auditing of quality.
 - 10.1.3 Management and control of quality assurance documentation, quality control of testing.
 - 10.1.4 Reports on testing, documentation systems.
- 10.2 Standardization
 - 10.2.1 Definition of standardization, principles of standards writing
 - 10.2.2 Standards, codes, specifications and procedures, their uses
 - 10.2.3 Reports and protocols

SPECIFIC OBJECTIVES:

- 10.1 Given the instructor's explanations, the student will be able to:
 - a) interpret and apply quality assurance procedures to the conducting 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.
- 10.2 Given the instructor's explanations, the student will be able to:
 - a) define standardization and discuss basic principles of standards writing;
 - b) discuss the benefit and applications of standards, codes, specifications and procedures.
 - c) write reports and keep records which meet the requirements of codes and standards.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Quality assurance manuals and typical documents
Films
Course notes

SUBJECT: 11. ORGANIZATION AND ADMINISTRATION OF NDT

CONTENTS:

11.1 Organization and administration of NDT

11.1.1 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.

11.1.2 Organization

- a) Equipment for work under way. Logistic provisions.
- b) Testing on production lines. Flow of materials. Work shifts.
- c) Maintenance of equipment and facilities.

11.1.3 Costs

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

11.1.4 Equipment selection and facility design

11.1.5 Operating procedures. Record-keeping

SPECIFIC OBJECTIVES:

11.1 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:

Blackboard
Transparencies
Course notes
Sample specifications and quotations
Sample procedures

SUBJECT: 12. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL

CONTENTS:

12.1 Qualification and Certification of personnel for NDT

- 12.1.1 National standards for the qualification and certification of personnel. Regional and international recommendations.
- 12.1.2 Training of personnel for NDT. Organization of courses and training in NDT methods.
- 12.1.3 Code of ethics.

SPECIFIC OBJECTIVES:

- 12.1 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:

Blackboard
Transparencies
Slides
Applicable standards and documents
Course notes

III. MAGNETIC TESTING (MT)

INSPECTION METHOD: MAGNETIC TESTING

S U B J E C T	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	8	16
2. PHYSICAL PRINCIPLES AND FUNDAMENTALS OF MAGNETIC PARTICLES	4	4	1
3. METHODS AND TECHNIQUES	8	8	2
4. EQUIPMENT AND ACCESSORIES	2	8	1
5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	4	4	2
6. PRESENTATION AND RECORDING OF RESULTS	2	2	1
7. INTERPRETATION OF RESULTS, LIMITATIONS	-	6	1
8. QUALITY ASSURANCE AND STANDARDIZATION	-	-	6
9. ORGANIZATION AND ADMINISTRATION OF NDT	-	-	8
10. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL	-	-	2
T O T A L	24	40	40

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Non-destructive testing of materials
 - 1.1.1 Definitions
 - 1.1.2 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 testing
 - d) Radiographic testing
 - e) Ultrasonic testing
 - f) Eddy current testing
 - g) Leak testing
 - 1.1.4 Limitations in the application of magnetic testing
- 1.2 Materials
 - 1.2.1 Properties of materials (metallic and non-metallic)
 - 1.2.2 Properties of metals
 - 1.2.3 Discontinuities
 - 1.2.4 Defects

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) define the nature of a 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.3 Processes and defects
 - 1.3.1 Primary processes and related defects
 - a) Melting
 - b) Pouring
 - c) Cooling
 - 1.3.2 Processing and related defects
 - a) Casting
 - b) Welding
 - c) Forging
 - d) Rolling
 - e) Heat treatment
 - f) Machining
 - g) Plating
 - h) Other processes
 - 1.3.3 Service and related defects
 - a) Overload
 - b) Fatigue
 - c) Corrosion
 - d) Brittle fracture
 - e) Others

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to:
 - a) list the various metallurgical processes of fabrication and bonding;
 - b) describe the possible defects associated with each type of process;
 - c) describe the possible defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Course notes
Samples of materials with typical defects

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

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Demonstration equipment
Transparencies
Slides
Blackboard

CONTENTS:

- 2.2 Magnetism (General principles)
 - 2.2.1 Magnetic poles
 - 2.2.2 Permanent magnets
 - 2.2.3 Temporary magnets
 - 2.2.4 Permeability
 - 2.2.5 Ferromagnetic, paramagnetic and diamagnetic materials
 - 2.2.6 Magnetic fields
 - 2.2.7 Lines of force
 - 2.2.8 Magnetic fields around the conductor
 - 2.2.9 Solenoid, electromagnet
 - 2.2.10 Magnetic flux
 - 2.2.11 Magnetization force
 - 2.2.12 Reluctance
 - 2.2.13 Hysteresis
 - 2.3 Visible and ultraviolet light
 - 2.4 Method of testing by magnetic particles
-

SPECIFIC OBJECTIVES:

- 2.2 Given the demonstrations and explanations in class, the student will 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 fields using magnets and iron particles.

EQUIPMENT AND RESOURCES:

Magnets
Magnetizable particles
Transparencies, slides and blackboard
Samples of types of lights
Lightmeters

SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

3.1 Methods of magnetization:

- 3.1.1 Longitudinal
- 3.1.2 Circular
- 3.1.3 Vectorial

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:

- Blackboard
- Transparencies
- Slides
- Basic equipment for magnetization
- Particles
- Magnetizable test pieces

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

3.4 Demagnetization techniques and verification of remnant 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Samples
Blackboard
Transparencies
Slides
Equipment for magnetization
Particles
Magnetizable test pieces
Gaussmeter and/or indicator

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

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Equipment for magnetization
Particles
Magnetizable test pieces
Equipment for demagnetization

CONTENTS:

- 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)
 - 4.3.5 Magnetic field measurement equipment
 - 4.3.6 Ultraviolet lamps
 - 4.3.7 Coloured and fluorescent powders
 - 4.3.8 Colour for increasing contrast

SPECIFIC OBJECTIVES:

- 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 and demonstrations, guided discussion and practice.

EQUIPMENT AND RESOURCES:

Blackboard
Slides
Samples
Blackboard
Accessories including various types of contact points
Graduated test vessel
Field indicators
Ultraviolet lamps
Protective hoods

SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

- 5.1 Interpretation of written instructions for application of tests by different techniques
- 5.2 Wet suspension of coloured and fluorescent particles
 - 5.2.1 Preparation
 - 5.2.2 Standards

SPECIFIC OBJECTIVES:

- 5.1 Given a set of written instructions, the student will be able to:
 - a) interpret the instructions correctly, performing 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 coloured 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 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
Slides

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 the JIS 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
JIS indicators
Field measuring instruments
Slides

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
 - 6.2.3 Using transfer methods
- 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 Given the results of a magnetic particle test, the student will be able to:
 - a) make a permanent record of the indications using photography and the transfer method;
 - b) enter the results obtained on the appropriate report form.
- 6.3 Given the results of magnetic particle 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:

Blackboard
Transparencies
Selection of forms
Samples
Test equipment
Work pieces containing discontinuities
Measuring equipment
Photographic camera
Adhesive tape
Slides

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Basic principles of NDT
 - 1.1.1 Definitions and methodology of applications of basic methods
 - 1.1.2 Fields of application of common methods
 - 1.1.3 Range and limitations of common methods
 - 1.1.4 Limitations in the application of magnetic testing
- 1.2 Materials and defects
 - 1.2.1 Structure of metals and alloys
 - 1.2.2 Properties of materials (metallic and non-metallic)
 - 1.2.3 Discontinuities and defects in metallic materials

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 material;
 - b) describe the various types of discontinuities and defects, their sources and their classification.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Blackboard
Course notes

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
- 1.4 Materials in service
 - 1.4.1 Behaviour of materials in service
 - 1.4.2 Service conditions leading to defects and failures:
 - a) Corrosion
 - b) Fatigue
 - c) Wear
 - d) Overload
 - e) Brittle fracture
 - 1.4.3 Concepts of rupture development in metals

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 the basic mechanisms giving rise to defects when the component is in service;
 - b) describe the defects that could arise during service and the general significance of each.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Samples of materials and defects

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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:

- 1.5 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, guided discussion and review of examples.

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Typical documents, i.e. codes

CONTENTS:

- 2.1 Electricity
 - 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
 - 2.2.1 Magnetic poles
 - 2.2.2 Permanent magnets
 - 2.2.3 Temporary magnets
 - 2.2.4 Ferro-, para-, and dia-magnetic materials
 - 2.2.5 Magnetic fields
 - 2.2.6 Lines of force
 - 2.2.7 Magnetic field around a conductor
 - 2.2.8 Solenoid
 - 2.2.9 Electromagnet
 - 2.2.10 Magnetic flux
 - 2.2.11 Magnetization force
 - 2.2.12 Reluctance
 - 2.2.13 Hysteresis

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 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 the magnetic field around a magnetic conductor, a non-magnetic conductor and a solenoid.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies. Blackboard. Samples. Course notes. Slides.

CONTENTS:

2.3 Magnetic field characteristics

2.3.1 Remanence

2.3.2 Permeability

2.3.3 Saturation

2.3.4 Normal and tangential components of the magnetic field

2.4 Terminology and abbreviations

SPECIFIC OBJECTIVES:

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and guided discussion.

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Blackboard
Course notes

INSPECTION METHOD: MAGNETIC TESTING

LEVEL: 2

SUBJECT: 2. PHYSICAL PRINCIPLES AND FUNDAMENTALS OF MAGNETIC PARTICLES

CONTENTS:

2.5 Electromagnetic waves

2.6 Visible and ultraviolet light

SPECIFIC OBJECTIVES:

- 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 and guided discussion.

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Blackboard
Course notes

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:

Blackboard. Transparencies. Slides. Course notes. Test pieces of different properties and dimensions. Equipment and accessories for applying the test.

SUBJECT: 3. METHODS AND TECHNIQUES

CONTENTS:

3.4 Testing techniques:

- 3.4.1 For work pieces of differing alloy, 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

3.5 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:
 - i) type of magnetization
 - ii) method of applying the particles
 - iii) type of current
 - iv) field direction
 - v) calculation of current requirements
 - b) determine the logical sequence of tests;
 - c) carry out a magnetic particle test.
- 3.5 Given the particles and the transport medium, the student will be able to:
 - a) obtain the correct concentration both for coloured and for 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:

Blackboard. Transparencies. Slides. Course notes. Test pieces of different properties and dimensions. Equipment and accessories for applying the test and for demagnetization.

SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

- 4.1 Knowledge of equipment:
 - 4.1.1 Permanent magnets
 - 4.1.2 Magnetic yoke
 - 4.1.3 Portable and stationary equipment
 - 4.1.4 Types of current and concepts of testing capacity
 - 4.1.5 Demagnetization equipment
 - 4.1.6 Maintenance and use of 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 on 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Course notes
Test pieces of different properties and dimensions
Equipment and accessories for applying the test

SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.2 Accessories:

- 4.2.1 Contact points
- 4.2.2 Vessels for checking bath concentration
- 4.2.3 Field indicators (Berthold test pieces)
- 4.2.4 Calibration pieces (JIS)
- 4.2.5 Magnetic field measurement equipment (Gaussmeter)
- 4.2.6 Ultraviolet lamps
- 4.2.7 Coloured and fluorescent powders
- 4.2.8 Colour for increasing contrast
- 4.2.9 Morphology of the particles

4.3 Selection of equipment appropriate to the nature of the test

4.4 Special equipment:

- 4.4.1 Portable equipment
- 4.4.2 Stationary installations
- 4.4.3 Automated equipment

SPECIFIC OBJECTIVES:

- 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 workpiece and the 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 limitations 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:

Blackboard. Transparencies. Slides. Course notes. Test pieces of different properties and dimensions. Equipment and accessories for applying the test.

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, with selection of equipment, field detection, intensity, type of current, selections of inspection medium, type of particle, 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 I 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 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:

Transparencies. Blackboard. 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.

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) transfer method using adhesive tape
 - d) knowledge of documentation systems
 - e) 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 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:

Transparencies
Blackboard
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
Photographic camera
Adhesive tape
Other recording media

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 testing and other methods of testing for surface and subsurface flaws
 - 7.5 Safety
 - 7.5.1 Implementation of industrial safety standards in facilities and equipment and in their operation
 - 7.5.2 Hazards of using toxic and inflammable materials
 - 7.5.3 Materials, equipment and accessories for the protection of persons and facilities
-

SPECIFIC OBJECTIVES:

- 7.1 Given a workpiece 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.
 - 7.2 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 testpiece.
 - 7.3 Given the instructor's explanation, the student will be able to determine the application and limitation of testing by magnetic particles.
 - 7.4 Given the instructor's explanation, the student will be able to compare magnetic 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 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:

Blackboard. 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.

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Technology of NDT

- 1.1.1 Definitions and methodology of applying NDT. Specific and distinctive characteristics of these methods.
- 1.1.2 Areas of NDT application. Quality control, maintenance. Defectology. Evaluation of properties.
- 1.1.3 Physical properties of the usual methods and their correlations with the examination requirements and defectology. Scope and limitations. Comparison of the most common methods.

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) discuss the methodology of applying NDT as well as the specific and distinctive characteristics of these methods;
 - b) determine the conditions for using NDT, evaluating its importance relative to the various types of problems and areas of application;
 - c) discuss the scope and the limitations of the various methods, correlating the physical principles with the test requirements, the defectology and the type of materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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 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 Plastic flow
- 1.2.10 Millwork, forging and power metallurgy
- 1.2.11 Machining fundamentals
- 1.2.12 Miscellaneous processes
- 1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

- 1.2 Given the instructor's explanations, the student will be able to:
- a) describe, interpret, analyze and evaluate the defectology 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 bondings;
 - d) recognize various types of compound materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

INSPECTION METHOD: MAGNETIC TESTING

LEVEL: 3

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 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

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

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 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 Wood 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 magnetics 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;
 - 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, instructor's explanations and guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Slides
Support material
Course notes

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 Remnant field

3.3 Indicating medium

3.3.1 Physical 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 for magnetization by yokes and coils;
- g) 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:

Blackboard
Slides
Transparencies
Course notes
Work pieces of varying characteristics and dimensions

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) 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:

Blackboard
Slides
Transparencies
Course notes
Work pieces of varying characteristics and dimensions

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, JIS, 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 Wood radiation lamps and UV meters

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:

Transparencies

Slides

Various magnetization equipment

Test pieces

Field measurement instruments

UV measurements. Standards and codes

SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

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:

Transparencies
Slides
Various magnetization equipment
Test pieces
Field measurement instruments
UV measurements
Standards and codes

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 Standard
 - 5.2.1 Specific standards for tests with magnetic particles (IRAM, 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:

Blackboard
Transparencies
Slides
Samples of design specifications
Standards and codes
Samples of general and specific procedures

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 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'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:

Transparencies
Blackboard
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
Photographic camera
Adhesive tape
Other recording media

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 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 workpiece 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 testpiece.
 - 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 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:

Blackboard
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

SUBJECT: 8. QUALITY ASSURANCE AND STANDARDIZATION

CONTENTS:

- 8.1 Quality assurance
 - 8.1.1 Basic principles for the application of quality assurance.
 - 8.1.2 Organization of quality assurance. Quality manual. Quality control. Auditing of quality
 - 8.1.3 Management and control of quality assurance documentation, quality control of testing
 - 8.1.4 Reports on testing, documentation systems
- 8.2 Standardization
 - 8.2.1 Definition of standardization, principles of standards writing
 - 8.2.2 Standards, codes, specifications and procedures, their uses
 - 8.2.3 Reports and protocols

SPECIFIC OBJECTIVES:

- 8.1 Given the instructor's explanations, the student shall demonstrate ability to:
 - a) interpret and apply quality assurance procedures to the conducting 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.
- 8.2 Given the instructor's explanations, the student shall demonstrate ability to:
 - a) define standardization and discuss basic principles of standards writing;
 - b) discuss the benefit and applications of standards, codes, specifications and procedures.
 - c) write reports and keep records which meet the requirements of codes and standards;

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Films
Course notes
Quality assurance manuals
Typical documents

SUBJECT: 9. ORGANIZATION AND ADMINISTRATION OF NDT

CONTENTS:

9.1 Organization and administration of NDT

9.1.1 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

9.1.2 Organization

- a) Equipment for work under way. Logistic provisions
- b) Testing on production lines. Flow of materials. Work shifts
- c) Maintenance of equipment and facilities

9.1.3 Costs

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

9.1.4 Equipment selection and facility design

9.1.5 Operating procedures and record-keeping

SPECIFIC OBJECTIVES:

9.1 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 task 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:

Blackboard
Transparencies
Slides
Course notes
Sample specifications and quotations
Sample procedures

SUBJECT: 10. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL

CONTENTS:

- 10.1 Qualification and Certification of personnel for NDT
 - 10.1.1 National standards for the qualification and certification of personnel. Regional and international recommendations
 - 10.1.2 Training of personnel for NDT. Organization of courses and training in NDT methods
 - 10.1.3 Code of ethics

SPECIFIC OBJECTIVES:

- 10.1 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:

Blackboard
Transparencies
Slides
Applicable standards and documents
Course notes

IV. LIQUID PENETRANT TESTING (PT)

INSPECTION METHOD: LIQUID PENETRANT TESTING

S U B J E C T	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	8	16
2. PHYSICAL PRINCIPLES OF THE TEST	2	4	2
3. PROCESSING	6	12	2
4. TEST EQUIPMENT AND MATERIALS	2	10	2
5. CODES, STANDARDS, PROCEDURES AND SAFETY	2	6	2
6. QUALITY ASSURANCE AND STANDARDIZATION	-	-	6
7. ORGANIZATION AND ADMINISTRATION OF NDT	-	-	8
8. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL	-	-	2
T O T A L	16	40	40

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Non-destructive testing of materials
 - 1.1.1 Definitions
 - 1.1.2 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 testing
 - d) Radiographic testing
 - e) Ultrasonic testing
 - f) Eddy current testing
 - g) Leak testing
 - 1.1.4 Limitations in the application of liquid penetrant testing
- 1.2 Materials
 - 1.2.1 Properties of materials (metallic and non-metallic)
 - 1.2.2 Properties of metals
 - 1.2.3 Discontinuities
 - 1.2.4 Defects

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) define the nature of a 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.3 Processes and defects
 - 1.3.1 Primary processes and related defects
 - a) Melting
 - b) Pouring
 - c) Cooling
 - 1.3.2 Processing and related defects
 - a) Casting
 - b) Welding
 - c) Forging
 - d) Rolling
 - e) Heat treatment
 - f) Machining
 - g) Plating
 - h) Other processes
 - 1.3.3 Service and related defects
 - a) Overload
 - b) Fatigue
 - c) Corrosion
 - d) Brittle fracture
 - e) Others

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to:
 - a) list the various metallurgical processes of fabrication and bonding;
 - b) describe the possible defects associated with each type of process;
 - c) describe the possible defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Course notes
Samples of materials with typical defects

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:

Blackboard
Transparencies
Slides
Chemical products
Penetrants
Work pieces

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 light 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:

Blackboard
Transparencies
Slides
Examples of penetrant materials

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, sanding, 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:

Blackboard. Transparencies. Slides.
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

SUBJECT: 3. PROCESSING

CONTENTS:

- 3.4 Application of the penetrant
 - 3.4.1 Various modes of application
 - 3.4.2 Penetration time
 - 3.4.3 Temperature
- 3.5 Removal of excess penetrant
 - 3.5.1 Various methods of removal depending on type of penetrant:
 - a) Water-dispersible
 - b) Water-soluble
 - c) Solvent-soluble
 - d) Post-emulsifiable
 - e) 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, selecting the established penetration temperature and time, in accordance with 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:

Blackboard. Transparencies. Slides.
Written instructions for liquid penetrant testing
Work piece, penetrant and accessory equipment
Drying material
Work pieces (from which the excess penetrant has been removed)

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 coloured 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:

Blackboard

Transparencies

Slides

Written instructions for liquid penetrant testing

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

SPECIFIC OBJECTIVES:

- 4.1 Given the instructor's explanations and a sample work piece, the student will be 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.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including guided discussion and practical work.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Penetrants, removers, developers, sample of work pieces
Ultrasonic cleaning equipment and degreasing steam
Aerosols

SUBJECT: 4. TEST EQUIPMENT AND MATERIALS

CONTENTS:

- 4.4 Installations for processing by immersion
- 4.5 Lighting
 - 4.5.1 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:

- 4.4 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:

Transparencies
Slides
Tanks, accessories and materials
Lighting equipment
Measurement devices for lighting
Ultraviolet lamps

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:

Blackboard
Transparencies
Codes covering liquid penetrants
Procedures
Equipment
Work pieces

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Basic principles of NDT

- 1.1.1 Definitions and methodology of applications of basic methods
- 1.1.2 Fields of application of common methods
- 1.1.3 Range and limitations of common methods
- 1.1.4 Limitations in the application of liquid penetrant testing

1.2 Materials and defects

- 1.2.1 Structure of metals and alloys
- 1.2.2 Properties of materials (metallic and non-metallic)
- 1.2.3 Discontinuities and defects in metallic materials

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 material;
 - b) describe the various types of discontinuities and defects, their sources and their classification.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Blackboard
Course notes

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
- 1.4 Materials in service
 - 1.4.1 Behaviour of materials in service
 - 1.4.2 Service conditions leading to defects and failures:
 - a) Corrosion
 - b) Fatigue
 - c) Wear
 - d) Overload
 - e) Brittle fracture
 - 1.4.3 Concepts of rupture development in metals

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 the basic mechanisms giving rise to defects when the component is in service;
 - b) describe the defects that could arise during service and the general significance of each.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Samples of materials and defects

INSPECTION METHOD: LIQUID PENETRANT TESTING

LEVEL: 2

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 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:

- 1.5 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, guided discussion and review of examples.

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Typical documents, i.e. codes

CONTENTS:

2.1 General description of the method

2.2 Properties of liquid penetrants:

2.2.1 Viscosity, surface tension, angle of contact between liquid and solid, capillarity

2.2.2 Behaviour of liquid 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 Lipophilic and hydrophilic 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 liquids

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:

a) identify the properties determining the behaviour of liquids in contact with solids;

b) explain the behaviour of liquid penetrants in the various stages of the process;

c) explain the factors effecting the behaviour 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 behaviour 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:

Blackboard

Transparencies

Slides

Work pieces illustrating different surface states and different materials

Work pieces with calibrated fissures

Penetrants for the various techniques for applying the test

Course notes

CONTENTS:

2.5 Luminous and ultraviolet spectrum

2.5.1 Colour and fluorescence

2.5.2 Colours

2.5.3 Absorption of light

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 Lipophilic and hydrophilic 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 behaviour of development powders in the dry state and in liquid suspension;
- b) explain the phenomena of colour and fluorescence;
- c) describe the behaviour 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 behaviour.

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

- a) list the various types of removers and explain their behaviour;
- 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 behaviour of the developers.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard

Transparencies

Slides

Samples of penetrant and cleaning materials

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, sanding, brushing, etc.)
 - 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 liquid penetrants, including the stage of precleaning.
- 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:

Blackboard
Transparencies
Slides
Laboratory for testing with penetrating liquids, equipped for applying the 6 standardized techniques

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

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Penetrant equipment and supplies
Samples
Photographic equipment
Report forms

SUBJECT: 3. PROCESSING

CONTENTS:

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:

- 3.6 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:

Blackboard
Transparencies
Slides
Penetrant equipment and supplies
Samples
Photographic equipment
Report forms

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, colour, fluorescence
- b) Behaviour: drop expansion, washability, corrosion, preservation, stability under light and UV radiation

4.1.2 Removers:

- a) Characteristic properties and behaviour
- b) Granulometry and apparent volume
- c) Sedimentation and compaction

4.1.3 Emulsifiers: characteristic properties and behaviour

4.1.4 Developers:

- a) Characteristic properties and behaviour
- 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:

Blackboard
Transparencies
Slides
Brochures and diagrams of facilities and equipment
Instrumentation for measuring and sample work pieces

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 installations
- 4.5 Light sources and lightmeters
 - 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:

Blackboard
Transparencies
Slides
Equipment and test pieces

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

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;

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Samples of standards and codes
Comparative tables

INSPECTION METHOD: LIQUID PENETRANT TESTING

LEVEL: 2

SUBJECT: 5. CODES, STANDARDS, PROCEDURES AND SAFETY.

CONTENTS:

- 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

SPECIFIC OBJECTIVES:

- 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Course notes
Transparencies
Slides
Safety equipment

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Technology of NDT

- 1.1.1 Definitions and methodology of applying NDT. Specific and distinctive characteristics of these methods.
- 1.1.2 Areas of NDT application. Quality control, maintenance. Defectology. Evaluation of properties.
- 1.1.3 Physical properties of the usual methods and their correlations with the examination requirements and defectology. Scope and limitations. Comparison of the most common methods.

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) discuss the methodology of applying NDT as well as the specific and distinctive characteristics of these methods;
 - b) determine the conditions for using NDT, evaluating its importance relative to the various types of problems and areas of application;
 - c) discuss the scope and the limitations of the various methods, correlating the physical principles with the test requirements, the defectology and the type of materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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 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 Plastic flow
- 1.2.10 Millwork, forging and power metallurgy
- 1.2.11 Machining fundamentals
- 1.2.12 Miscellaneous processes
- 1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

- 1.2 Given the instructor's explanations, the student will be able to:
- a) describe, interpret, analyze and evaluate the defectology 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 bondings;
 - d) recognize various types of compound materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

INSPECTION METHOD: LIQUID PENETRANT TESTING

LEVEL: 3

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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

SPECIFIC OBJECTIVES:

1.3 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

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 Colour and fluorescence. Light absorption phenomena. Beer's law. Absorption spectrometry. Fluorescent emission spectra
- 2.6 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:

Blackboard. Transparencies. Slides. Tables and graphs. Laboratory material for demonstration of physicochemical principles. Course notes.

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

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 precleaning of the specimens to be tested;
- 3.3 Given the instructor's explanations, the student will be able to evaluate, select and apply various methods of applying the penetrant to specimens of different configurations.

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:

Blackboard
Transparencies
Slides
Laboratory, equipment and accessories for testing
Products for the various testing techniques
Specimens for testing

SUBJECT: 3. PROCESSING

CONTENTS:

- 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:

- 3.4 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 and guided discussion of the stages of applications of the test and the results.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Laboratory, equipment and accessories for testing
Products for the various testing techniques
Specimens for testing

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:

Blackboard
Transparencies
Slides
Laboratory, equipment and accessories for testing
Products for the various testing techniques
Specimens for testing

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 behaviour
 - 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

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including practical work on behaviour 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:

Blackboard
Transparencies
Slides
Laboratory with equipment, materials and suitable work pieces

SUBJECT: 4. TEST EQUIPMENT AND MATERIALS

CONTENTS:

- 4.3 Equipment and accessories applicable to the test under way
 - 4.3.1 Pulverization systems and equipment for liquids
 - 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:

- 4.3 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;
 - b) select, install and adjust test installations for manual or automated testing in plants.
- 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 behaviour 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:

Blackboard
Transparencies
Slides
Laboratory with equipment, materials and suitable work pieces.

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:

Blackboard
Transparencies
Slides
Sample codes, standards, specifications and procedures

SUBJECT: 6. QUALITY ASSURANCE AND STANDARDIZATION

CONTENTS:

6.1 Quality assurance

- 6.1.1 Basic principles for the application of quality assurance
- 6.1.2 Organization of quality assurance. Quality manual. Quality control. Auditing of quality
- 6.1.3 Management and control of quality assurance documentation, quality control of testing
- 6.1.4 Reports on testing, documentation systems

6.2 Standardization

- 6.2.1 Definition of standardization, principles of standards writing
- 6.2.2 Standards, codes, specifications and procedures, their uses
- 6.2.3 Reports and protocols

SPECIFIC OBJECTIVES:

- 6.1 Given the instructor's explanations, the student will be able to:
 - a) interpret and apply quality assurance procedures to the conducting 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.
- 6.2 Given the instructor's explanations, the student will be able to:
 - a) define standardization and discuss basic principles of standards writing;
 - b) discuss the benefit and applications of standards, codes, specifications and procedures;
 - c) write reports and keep records which meet the requirements of codes and standards.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Quality assurance manuals
Films
Course notes
Typical documents

SUBJECT: 7. ORGANIZATION AND ADMINISTRATION OF NDT

CONTENTS:

7.1 Organization and administration of NDT

7.1.1 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.

7.1.2 Organization

- a) Equipment for work under way. Logistic provisions.
- b) Testing on production lines. Flow of materials. Work shifts.
- c) Maintenance of equipment and facilities.

7.1.3 Costs

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

7.1.4 Equipment selection and facility design

7.1.5 Operating procedures. Record-keeping

SPECIFIC OBJECTIVES:

7.1 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:

Blackboard
Transparencies
Course notes
Sample specifications and quotations
Sample procedures

INSPECTION METHOD: LIQUID PENETRANT TESTING

LEVEL: 3

SUBJECT: 8. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL

CONTENTS:

8.1 Qualification and certification of NDT personnel

- 8.1.1 National standards for the qualification and certification of personnel.
Regional and international recommendations
- 8.1.2 Training of personnel for NDT. Organization of courses and training in NDT methods
- 8.1.3 Code of ethics

SPECIFIC OBJECTIVES:

- 8.1 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:

Blackboard
Transparencies
Slides
Applicable standards and documents
Course notes

V. EDDY CURRENT TESTING (ET)

INSPECTION METHOD: EDDY CURRENT TESTING

S U B J E C T	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	8	16
2. PHYSICAL PRINCIPLES	8	8	4
3. INSTRUMENTATION	8	16	12
4. TESTING PROCEDURES	14	24	12
5. APPLICATIONS	4	20	12
6. PRESENTATION OF RESULTS	2	4	8
7. QUALITY ASSURANCE AND STANDARDIZATION	-	-	6
8. ORGANIZATION AND ADMINISTRATION OF NDT	-	-	8
9. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL	-	-	2
T O T A L	40	80	80

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Non-destructive testing of materials
 - 1.1.1 Definitions
 - 1.1.2 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 testing
 - d) Radiographic testing
 - e) Ultrasonic testing
 - f) Eddy current testing
 - g) Leak testing
 - 1.1.4 Limitations in the application of eddy current testing
- 1.2 Materials
 - 1.2.1 Properties of materials (metallic and non-metallic)
 - 1.2.2 Properties of metals
 - 1.2.3 Discontinuities
 - 1.2.4 Defects

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) define the nature of a 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.3 Processes and defects
 - 1.3.1 Primary processes and related defects
 - a) Melting
 - b) Pouring
 - c) Cooling
 - 1.3.2 Processing and related defects
 - a) Casting
 - b) Welding
 - c) Forging
 - d) Rolling
 - e) Heat treatment
 - f) Machining
 - g) Plating
 - h) Other processes
 - 1.3.3 Service and related defects
 - a) Overload
 - b) Fatigue
 - c) Corrosion
 - d) Brittle fracture
 - e) Others

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to:
 - a) list the various metallurgical processes of fabrication and bonding;
 - b) describe the possible defects associated with each type of process;
 - c) describe the possible defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Course notes
Samples of materials with typical defects

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

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Sample magnets and iron filings

SUBJECT: 2. PHYSICAL PRINCIPLES

CONTENTS:

- 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:

- 2.4 Given the instructor's explanation, the student will be able to describe the electrical and magnetic fields 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:

Blackboard
Transparencies
Slides
Selection of typical geometric shapes used in eddy current testing

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
- 3.3 Technology and practical characteristics of probes
 - 3.3.1 Design technology
 - 3.3.2 Manufacturing technology
 - 3.3.3 Electrical parameters
 - 3.3.4 Maintenance

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

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Examples of eddy current probes of various configurations

SUBJECT: 3. INSTRUMENTATION

CONTENTS:

- 3.4 Working principle 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, monochannel and specialized 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, magnetic tape recorders, 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 and state the most appropriate application for each.
 - 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:

Blackboard
Transparencies
Slides
Demonstration equipment

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 Centering, fill factor
 - 4.4.3 Sensitivity
 - 4.4.4 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:

Blackboard
Transparencies
Slides
Eddy current equipment and accessories
Work pieces of various geometries and sizes

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

SPECIFIC OBJECTIVES:

- 4.5 Given the instructor's explanation, the student will be able to describe 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 including the recording of indications.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Eddy current equipment and accessories
Work pieces of various geometries and sizes
Reference standards

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 Main types of discontinuities detected by eddy current testing
 - 5.2.1 Discontinuities arising from production
 - 5.2.2 Discontinuities arising during hot or cold processing
 - 5.2.3 Discontinuities arising during service
- 5.3 Defect detection
 - 5.3.1 Absolute measurement
 - 5.3.2 Differential measurement
- 5.4 Thickness measurement
 - 5.4.1 Thickness of a product
 - 5.4.2 Thickness of coating
- 5.5 Measurement of product composition
 - 5.5.1 Measuring by electrical conductivity

SPECIFIC OBJECTIVES:

- 5.1 Given the instructor's explanation, the student will be able to describe how defects of various sizes are characterized by eddy current results.
- 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 absolute and differential measurement 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.
- 5.5 Given the instructor's explanation, the student will be able to describe the method for measuring product composition by measuring electrical conductivity.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Equipment and test pieces of various shapes and sizes containing defects

SUBJECT: 6. PRESENTATION OF RESULTS

CONTENTS:

6.1 Written instructions

6.2 Report preparation

SPECIFIC OBJECTIVES:

6.1 Given the instructor's explanation, the student will be able to carry out an eddy current inspection following written instructions.

6.2 Given 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:

Blackboard
Transparencies
Slides
Sample written instructions and associated test pieces
Eddy current equipment
Report forms

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Basic principles of NDT
 - 1.1.1 Definitions and methodology of applications of basic methods
 - 1.1.2 Fields of application of common methods
 - 1.1.3 Range and limitations of common methods
 - 1.1.4 Limitations in the application of eddy current testing
- 1.2 Materials and defects
 - 1.2.1 Structure of metals and alloys
 - 1.2.2 Properties of materials (metallic and non-metallic)
 - 1.2.3 Discontinuities and defects in metallic materials

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 material;
 - b) describe the various types of discontinuities and defects, their sources and their classification.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Blackboard
Course notes

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
- 1.4 Materials in service
 - 1.4.1 Behaviour of materials in service
 - 1.4.2 Service conditions leading to defects and failures:
 - a) Corrosion
 - b) Fatigue
 - c) Wear
 - d) Overload
 - e) Brittle fracture
 - 1.4.3 Concepts of rupture development in metals

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 the basic mechanisms giving rise to defects when the component is in service;
 - b) describe the defects that could arise during service and the general significance of each.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

- Transparencies
- Films
- Slides
- Blackboard
- Course notes
- Samples of materials and defects

INSPECTION METHOD: EDDY CURRENT TESTING

LEVEL: 2

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 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:

- 1.5 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, guided discussion and review of examples.

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Typical documents, i.e. codes

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
 - 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

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Sample magnets and iron filings

SUBJECT: 2. PHYSICAL PRINCIPLES

CONTENTS:

- 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:

- 2.3 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:

Blackboard
Transparencies
Slides

SUBJECT: 2. PHYSICAL PRINCIPLES

CONTENTS:

- 2.5 Eddy current distribution
 - 2.5.1 Plane conductors
 - a) Variation of amplitude and phase of current
 - b) Depth of standard penetration
 - c) Defect reaction according to position
 - 2.5.2 Cylindrical bars
 - a) Characteristic frequencies
 - b) Variation of amplitude and phase of currents
 - c) Depth of standard penetration
 - d) Defect reaction according to position
 - 2.5.3 Tubes
 - a) Characteristic frequencies
 - b) Variations of amplitude and phase
 - c) Depth of standard penetration
 - d) Defect reaction according to position

SPECIFIC OBJECTIVES:

- 2.5 Given the instructor's explanation, the student will be able to describe and explain the electrical and magnetic fields 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:

Blackboard
Transparencies
Slides
Selection of typical geometric shapes used in eddy current testing

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 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 Focussing 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 focussing 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:

Blackboard
Transparencies
Slides
Examples of eddy current probes of various configurations

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 Working principle of eddy current equipment
 - 3.5.1 Transmission
 - 3.5.2 Reception
 - 3.5.3 Data presentation
- 3.6 Main functions and adjustments of the equipment
 - 3.6.1 Oscillator
 - 3.6.2 Energizing device
 - 3.6.3 Measuring system
 - 3.6.4 Balance
 - 3.6.5 Amplifier and filter
 - 3.6.6 Demodulator
 - 3.6.7 Display (ellipse, time-base, impedance plane, vector point)
 - 3.6.8 Phase rotation
 - 3.6.9 Output filter

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 presentation, the student will be able to explain the working principles of eddy current equipment.
- 3.6 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Examples of eddy current probes of various configurations

SUBJECT: 3. INSTRUMENTATION

CONTENTS:

- 3.7 Different types of eddy current equipment
 - 3.7.1 Monoparameter, monochannel and specialized equipment
 - 3.7.2 Multiparameter and multichannel equipment
- 3.8 Auxiliary devices
 - 3.8.1 Auxiliary devices for signal acquisition
 - 3.8.2 Driving mechanism, saturating unit, demagnetizer
 - 3.8.3 Equipment for signal storage: stripchart recorders, magnetic tape recorders, digital memories
 - 3.8.4 System for automatic processing of signals

SPECIFIC OBJECTIVES:

- 3.7 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.
- 3.8 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, demonstration and guided discussion.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Demonstration equipment

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 Centering - fill factor
 - 4.4.3 Sensitivity
 - 4.4.4 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:

Blackboard
Transparencies
Eddy current equipment and accessories
Work pieces of various geometries and sizes

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:

Blackboard
Transparencies
Slides
Eddy current equipment and accessories
Work pieces of various geometries and sizes

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:

Blackboard
Transparencies
Slides
Equipment and test pieces of various shapes and sizes containing defects

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 Defect detection
 - 5.6.1 Absolute measurement
 - 5.6.2 Differential measurement
 - 5.7 Thickness measurement
 - 5.7.1 Thickness of a product
 - 5.7.2 Thickness of coating
 - 5.8 Measurement of product composition
 - 5.8.1 Measuring by electrical conductivity
 - 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 how differential and absolute measurement are applied in eddy current testing.
 - 5.7 Given the instructor's explanation, the student will be able to explain the means of thickness measurement by eddy currents.
 - 5.8 Given the instructor's explanation, the student will be able to describe the method for measuring product composition by measuring electrical conductivity.
 - 5.9 Given the instructor's explanation, the student will be able to explain the principles and applications of multifrequency eddy current test equipment.
-

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
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

SUBJECT: 6. PRESENTATION OF RESULTS

CONTENTS:

- 6.1 Codes and standards which apply to eddy current testing
- 6.2 Specifications and procedures which apply to the method
- 6.3 Inspection techniques and their use
- 6.4 Inspection reports
- 6.5 Safety
 - 6.5.1 Implementation of industrial safety standards in facilities and equipment and in their operation

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 apply specifications and procedures which are used in eddy current testing.
- 6.3 Given the instructor's explanation, the student will be able to develop inspection techniques for inspection problems to which the eddy current method applies.
- 6.4 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.
- 6.5 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:

Blackboard
Transparencies
Slides
Sample written procedures and associated test pieces
Eddy current equipment
Report forms
Codes, standards and specifications

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Technology of NDT

- 1.1.1 Definitions and methodology of applying NDT. Specific and distinctive characteristics of these methods.
- 1.1.2 Areas of NDT application. Quality control, maintenance. Defectology. Evaluation of properties.
- 1.1.3 Physical properties of the usual methods and their correlations with the examination requirements and defectology. Scope and limitations. Comparison of the most common methods.

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) discuss the methodology of applying NDT as well as the specific and distinctive characteristics of these methods;
 - b) determine the conditions for using NDT, evaluating its importance relative to the various types of problems and areas of application;
 - c) discuss the scope and the limitations of the various methods, correlating the physical principles with the test requirements, the defectology and the type of materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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 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 Plastic flow
- 1.2.10 Millwork, forging and power metallurgy
- 1.2.11 Machining fundamentals
- 1.2.12 Miscellaneous processes
- 1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

- 1.2 Given the instructor's explanations, the student will be able to:
- a) describe, interpret, analyze and evaluate the defectology 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 bondings;
 - d) recognize various types of compound materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

INSPECTION METHOD: EDDY CURRENT TESTING

LEVEL: 3

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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

SPECIFIC OBJECTIVES:

1.3 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

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

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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides

SUBJECT: 2. PHYSICAL PRINCIPLES

CONTENTS:

- 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:

- 2.3 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:

Blackboard
Transparencies
Slides
Selection of shapes encountered in eddy current testing

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 measurement
 - 3.1.3 Test coil arrangements: encircling coil, internal coil, surface coil, hybrid coil
 - 3.1.4 Focussing 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 from 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 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 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:

Blackboard
Transparencies
Slides
Examples of eddy current probes of various configurations
Eddy current equipment

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 Multiparameter equipment: two way equipment, multifrequency equipment
- 3.6 Auxiliary devices
 - 3.6.1 Auxiliary devices for signal acquisition
 - 3.6.2 Driving mechanism, saturating unit, demagnetizer
 - 3.6.3 Equipment for signal storage: stripchart recorders, magnetic tape recorders, 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:

Blackboard
Transparencies
Slides
Eddy current equipment
Demonstration equipment

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 Centering, fill factor
 - 4.4.3 Sensitivity
 - 4.4.4 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:

Blackboard
Transparencies
Slides
Eddy current equipment and accessories
Work pieces of various geometries and sizes

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:

Blackboard
Transparencies
Slides
Eddy current equipment and accessories
Work pieces of various geometries and sizes
Reference standards

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 will 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 measurement 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:

Blackboard
Transparencies
Slides
Equipment and test pieces of various shapes and sizes containing defects

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

5.7 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, reproducibility 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:

Blackboard

Transparencies

Slides

Equipment and test pieces of various thicknesses and with coatings

Test pieces for demonstration of conductivity testing

Equipment of test pieces of various geometries, sizes and characteristics

SUBJECT: 6. PRESENTATION OF RESULTS

CONTENTS:

- 6.1 Codes and standards which apply to eddy current testing
- 6.2 Specifications and procedures which apply to the method
- 6.3 Inspection techniques and their use
- 6.4 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 analyze, evaluate and develop specifications and procedures to be used in eddy current testing.
- 6.3 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.
- 6.4 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:

Blackboard
Transparencies
Slides
Sample written procedures and associated test pieces
Eddy current equipment
Report forms
Codes, standards and specifications

CONTENTS:

7.1 Quality assurance

- 7.1.1 Basic principles for the application of quality assurance.
- 7.1.2 Organization of quality assurance. Quality manual. Quality control. Auditing of quality.
- 7.1.3 Management and control of quality assurance documentation, quality control of testing.
- 7.1.4 Reports on testing, documentation systems.

7.2 Standardization

- 7.2.1 Definition of standardization, principles of standards writing
- 7.2.2 Standards, codes, specifications and procedures, their uses
- 7.2.3 Reports and protocols

SPECIFIC OBJECTIVES:

- 7.1 Given the instructor's explanations, the student will be able to:
 - a) interpret and apply quality assurance procedures to the conducting 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.
- 7.2 Given the instructor's explanations, the student will be able to:
 - a) define standardization and discuss basic principles of standards writing;
 - b) discuss the benefit and applications of standards, codes, specifications and procedures;
 - c) write reports and keep records which meet the requirements of codes and standards.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Quality assurance manuals and typical documents
Films
Course notes

CONTENTS:

8.1 Organization and administration of NDT

8.1.1 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.

8.1.2 Organization

- a) Equipment for work under way. Logistic provisions.
- b) Testing on production lines. Flow of materials. Work shifts.
- c) Maintenance of equipment and facilities.

8.1.3 Costs

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

8.1.4 Equipment selection and facility design.

8.1.5 Operating procedures. Record-keeping.

SPECIFIC OBJECTIVES:

8.1 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:

Blackboard
Transparencies
Slides
Course notes
Sample specifications and quotations
Sample procedures

CONTENTS:

- 9.1 Qualification and Certification of personnel for NDT
- 9.1.1 National standards for the qualification and certification of personnel. Regional and international recommendations.
 - 9.1.2 Training of personnel for NDT. Organization of courses and training in NDT methods.
 - 9.1.3 Code of ethics.

SPECIFIC OBJECTIVES:

- 9.1 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:

Blackboard
Transparencies
Slides
Applicable standards and documents
Course notes

VI. LEAK TESTING (LT)

INSPECTION METHOD: LEAK TESTING

S U B J E C T	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	8	12	12
2. PHYSICAL PRINCIPLES OF THE TEST	4	12	12
3. TEST TECHNIQUES	6	32	24
4. EQUIPMENT AND ACCESSORIES	16	12	12
5. DOCUMENTATION OF THE TEST	2	2	2
6. CODES, STANDARDS, PROCEDURES AND SAFETY	4	10	8
7. ORGANIZATION AND ADMINISTRATION OF NDT	-	-	8
8. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL			2
T O T A L	40	80	80

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Non-destructive testing of materials
 - 1.1.1 Definitions
 - 1.1.2 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 testing
 - d) Radiographic testing
 - e) Ultrasonic testing
 - f) Eddy current testing
 - g) Leak testing
 - 1.1.4 Limitations in the application of leak testing
- 1.2 Materials
 - 1.2.1 Properties of materials (metallic and non-metallic)
 - 1.2.2 Properties of metals
 - 1.2.3 Discontinuities
 - 1.2.4 Defects

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) define the nature of a 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

- Blackboard
- Transparencies
- Slides
- Film (if available)
- Course notes
- Samples of various materials

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.3 Processes and defects
 - 1.3.1 Primary processes and related defects
 - a) Melting
 - b) Pouring
 - c) Cooling
 - 1.3.2 Processing and related defects
 - a) Casting
 - b) Welding
 - c) Forging
 - d) Rolling
 - e) Heat treatment
 - f) Machining
 - g) Plating
 - h) Other processes
 - 1.3.3 Service and related defects
 - a) Overload
 - b) Fatigue
 - c) Corrosion
 - d) Brittle fracture
 - e) Others

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to:
 - a) list the various metallurgical processes of fabrication and bonding;
 - b) describe the possible defects associated with each type of process;
 - c) describe the possible defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Course notes
Samples of materials with typical defects

INSPECTION METHOD: LEAK TESTING

LEVEL: 1

SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

- 2.1 General equation of gases. Pressurization of gases. Temperature effects. Variations in atmospheric pressure and changes in vapour 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.
- 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:

Transparencies
Films
Course notes

CONTENTS:

- 3.1 Techniques for the application of leak testing:
 - a) Bubble test
 - b) Pressure measurement
 - c) Halogens detection
 - d) Helium detection
 - e) Radioactive tracers
 - f) Liquid penetrants and chemical tracers
- 3.2 Leaks detection 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 with systems of reference. Relative terminology. Gas pressurization. Effects of changes in temperature, vapour pressure and atmospheric pressure. Application to examination of vessels.

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 operative 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) know: terminology; conditions for gas pressurization; effect of temperature changes and vapour pressure.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Films
Course notes
Samples
Bubble test equipment and accessories

CONTENTS:

- 3.4 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.
- 3.5 Test with helium spectrometers: operative conditions for leak test with helium spectrometer. Operation principles. Relative terminology. Operation and maintenance of helium mass spectrometers. Calibration for the different test techniques. Operation of vacuum pumps. Test techniques. Percentage of helium in tracer fluid. Use of sniffer, 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.
- 3.6 Leak testing in accordance with written instructions
-

SPECIFIC OBJECTIVES:

- 3.4 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.
- 3.5 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 sniffer and the calibration of standard leaks.
- 3.6 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:

Blackboard
Transparencies
Films
Course notes
Bubble test equipment and accessories

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.
- 4.4 Helium-mass spectrometer. Vacuum unit, control cabinet, spectrometer, sniffer.
- 4.5 Accessories: vacuum pumps, vacuum valves, vacuum pipes, vacuum connectors, compound mastics for sealing to vacuum. Calibrated leaks.

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:

Blackboard
Transparencies
Films
Course notes
Equipment for different leak tests and accessories

INSPECTION METHOD: LEAK TESTING

LEVEL: 1

SUBJECT: 5. DOCUMENTATION OF THE TEST

CONTENTS:

- 5.1 Registration of operative conditions on test forms and presentation of data sheets
- 5.2 Listing of anomalies observed during preparation and execution of test

SPECIFIC OBJECTIVES:

- 5.1 Given the instructor's explanations, the student will be able to fill out test forms and data sheets relating to the test.
- 5.2 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:

Transparencies
Films
Course notes
Samples

INSPECTION METHOD: LEAK TESTING

LEVEL: 1

SUBJECT: 6. CODES, STANDARDS, SPECIFICATIONS AND SAFETY

CONTENTS:

- 6.1 General knowledge
 - 6.1.1 National, regional and international codes and standards
 - 6.1.2 General knowledge of specifications
- 6.2 Industrial safety standards
- 6.3 Instructions for the test
 - 6.3.1 Interpretation

SPECIFIC OBJECTIVES:

- 6.1 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.
- 6.2 Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out.
- 6.3 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:

Blackboard
Transparencies
Course notes
Leak testing codes
Procedures
Equipment
Work pieces

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Basic principles of NDT
 - 1.1.1 Definitions and methodology of applications of basic methods
 - 1.1.2 Fields of application of common methods
 - 1.1.3 Range and limitations of common methods
 - 1.1.4 Limitations in the application of leak testing
- 1.2 Materials and defects
 - 1.2.1 Structure of metals and alloys
 - 1.2.2 Properties of materials (metallic and non-metallic)
 - 1.2.3 Discontinuities and defects in metallic materials

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 material;
 - b) describe the various types of discontinuities and defects, their sources and their classification.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Blackboard
Course notes

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
- 1.4 Materials in service
 - 1.4.1 Behaviour of materials in service
 - 1.4.2 Service conditions leading to defects and failures:
 - a) Corrosion
 - b) Fatigue
 - c) Wear
 - d) Overload
 - e) Brittle fracture
 - 1.4.3 Concepts of rupture development in metals

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 the basic mechanisms giving rise to defects when the component is in service;
 - b) describe the defects that could arise during service and the general significance of each.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Samples of materials and defects

INSPECTION METHOD: LEAK TESTING

LEVEL: 2

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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:

- 1.5 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, guided discussion and review of examples.

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Typical documents, i.e. codes

SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

- 2.1 General equation of gases. Pressurization of gases. Effects of temperature, atmospheric pressure and vapour pressure.
- 2.2 Basic knowledge of leaks and leakages
 - 2.2.1 Basic knowledge of leaks and leakage through a confining wall. Real leaks and virtual leaks. Different types of fluid flow in the leakage.
 - 2.2.2 Leak conductance. Sensitivity of detector and sensitivity of test. Calculation of leakages.
 - 2.2.3 Units of pressure, volume and flow rate in leak testing.
- 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 of 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:

Transparencies
Blackboard
Course notes
Films

CONTENTS:

- 3.1
- 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

- Blackboard
- Transparencies
- Course notes
- Films
- Equipment for bubble and halogen tests

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.
- 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.
- 3.2.3 Test by detection of halogens: Operating conditions of the halogen diode detector. Operating principles. Relative terminology. 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. Sensitivity of the test.

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:

Blackboard
Transparencies
Course notes
Films
Equipment for bubble and halogen testing

CONTENTS:

3.2.4

3.2.4.1 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.

3.2.4.2 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.

3.3 Other techniques: radiation tracers, liquid penetrants, chemical reagents

3.4 Relative sensitivity and scope of application of the different techniques

3.5 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.

3.3 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.

3.4 Given the instructor's explanations, the student will be able to describe the relative sensitivity and field of application of the different techniques.

3.5 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:

Blackboard

Transparencies

Course notes

Films

Equipment for leak testing using helium spectrometer, radioactive tracers, dye penetrants and chemical agents

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. Standardization leaks.
- 4.3 Helium mass spectrometer: vacuum unit, control panel, spectrometer, sniffer.
- 4.4 Accessories: vacuum pumps, vacuum valves, vacuum pipes, connectors for vacuum, sealing compound for vacuum, calibrated leaks.

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:

Blackboard
Transparencies
Course notes
Films
Equipment for different leak tests and accessories

SUBJECT: 5. DOCUMENTATION OF THE TEST

CONTENTS:

5.1 Interpretation of test procedures and preparation of written instructions for Level 1 operators. Preparation of data sheets. Preparation of reports.

SPECIFIC OBJECTIVES:

- 5.1 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.

SPECIFIC OBJECTIVES:

Instructor's presentation including lectures, demonstrations, and guided discussions arising from student experience.

EQUIPMENT AND RESOURCES:

- Blackboard
- Transparencies
- Course notes
- Films
- Samples

INSPECTION METHOD: LEAK TESTING

LEVEL: 2

SUBJECT: 6. CODES, STANDARDS, PROCEDURES AND SAFETY

CONTENTS:

- 6.1 Standards applicable to leak testing
 - 6.1.1 Test methods
 - 6.1.2 Materials for the test (ASTM, DIN, MIL, IRAM)
 - 6.1.3 ASME code
- 6.2 Test specifications and procedures
 - 6.2.1 Interpretation
 - 6.2.2 Formulation of instructions for the test
- 6.3 National standards for leak testing and testing personnel
 - 6.3.1 Quality control of the test and procedure for its administration
 - 6.3.2 Quality assurance requirements

SPECIFIC OBJECTIVES:

- 6.1 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.
- 6.2 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 Level 1;
 - c) formulate the information required for documenting the test and presenting reports.
- 6.3 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:

Blackboard
Transparencies
Samples of standards and codes
Comparative tables

INSPECTION METHOD: LEAK TESTING

LEVEL: 2

SUBJECT: 6. CODES, STANDARDS, PROCEDURES AND SAFETY

CONTENTS:

- 6.4 Problems of industrial safety in the use of chemical and inflammable products
 - 6.4.1 Applicable safety standards
 - 6.4.2 Drafting of safety instructions for the personnel involved
 - 6.4.3 Safety factors applicable to the test

SPECIFIC OBJECTIVES:

- 6.4 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) list the applicable safety standards;
 - c) prepare safety instructions for application of the test.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, guided discussions, demonstrations and supervised practice.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Safety equipment

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Technology of NDT

- 1.1.1 Definitions and methodology of applying NDT. Specific and distinctive characteristics of these methods.
- 1.1.2 Areas of NDT application. Quality control, maintenance. Defectology. Evaluation of properties.
- 1.1.3 Physical properties of the usual methods and their correlations with the examination requirements and defectology. Scope and limitations. Comparison of the most common methods.

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) discuss the methodology of applying NDT as well as the specific and distinctive characteristics of these methods;
 - b) determine the conditions for using NDT, evaluating its importance relative to the various types of problems and areas of application;
 - c) discuss the scope and the limitations of the various methods, correlating the physical principles with the test requirements, the defectology and the type of materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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 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 Plastic flow
- 1.2.10 Millwork, forging and power metallurgy
- 1.2.11 Machining fundamentals
- 1.2.12 Miscellaneous processes
- 1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

- 1.2 Given the instructor's explanations, the student will be able to:
- a) describe, interpret, analyze and evaluate the defectology 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 bondings;
 - d) recognize various types of compound materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

INSPECTION METHOD: LEAK TESTING

LEVEL: 3

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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

SPECIFIC OBJECTIVES:

1.3 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

CONTENTS:

- 2.1 General equation of gases. Pressurization of gases. Effects of temperature, atmospheric pressure and vapour pressure. Reduction of pressure and data corrections. Analysis of temperature and dew point data.
- 2.2 Basic knowledge of leaks and leakages
 - 2.2.1 Basic knowledge of leaks and leakage through a confining wall. Real and virtual leaks. General theory of viscous fluids. Bernoulli's equations.
 - 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.
 - 2.2.3 Units of pressure, volume and flow rate, used in leak testing. Expression of leakage in power units. Calculation and conversions.
- 2.3 Fluid tracers. Liquid and gaseous tracers. Physical principles for the detection of the 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 calculations 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:
 - 2.2.1
 - 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.
 - 2.2.2
 - a) define leak conductance;
 - b) know the influence of conductance on different flow conditions;
 - c) make calculations of leakage for the different techniques;
 - d) make calculations for producing vacuum in confined systems;
 - e) make calculations of sensitivity of the test according to the detector sensitivity and applied technique.
 - 2.2.3 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:

Blackboard. Transparencies. Course notes.

SUBJECT: 3. TEST TECHNIQUES

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.

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, solution of problems and development of supervised practical experiments.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes
Equipment for bubble and pressure testing

CONTENTS:

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.

SPECIFIC OBJECTIVES:

- 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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, solution of problems and development of supervised practical experiments.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes
Equipment for bubble and pressure testing

SUBJECT: 3. TEST TECHNIQUES

CONTENTS:

- 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.
- 3.4 Comparative analysis of applicability of different test techniques for compliance with examination specifications.

SPECIFIC OBJECTIVES:

- 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.
- 3.4 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 experiments.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes
Equipment for testing by halogen detection and helium spectrometry

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 unit, control panel, spectrometer, sniffer.
- 4.4 Accessories: vacuum pumps, vacuum valves, vacuum pipe lines, vacuum connectors, sealing compound, calibrated leaks.
- 4.5
 - 4.5.1 Set-up and verification of equipment and accessories
 - 4.5.2 Selection of equipment and accessories. 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) knowledge of the constructive characteristics and operational parameters of the various equipment and accessories applicable to the different testing methods and techniques;
 - b) knowledge of the setting-up and verification requirements of the various tests equipment and accessories.
 - c) capability for the design of reception, control and verification tests for equipment and accessories;
 - d) 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:

Blackboard
Transparencies
Course notes
Diverse equipment for leak detection

INSPECTION METHOD: LEAK TESTING

LEVEL: 3

SUBJECT: 5. DOCUMENTATION OF THE TEST

CONTENTS:

- 5.1 Test procedures in accordance with specifications and standards
- 5.2 Test and data sheets. Inspection protocols.

SPECIFIC OBJECTIVES:

- 5.1 Given the instructor's explanations, the student will be able to prepare test procedures in accordance with specifications and standards.
- 5.2 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:

Blackboard
Transparencies
Course notes
Standards and codes
Specifications and procedures

INSPECTION METHOD: LEAK TESTING

LEVEL: 3

SUBJECT: 6. CODES, STANDARDS, PROCEDURES AND SAFETY

CONTENTS:

- 6.1 Examination specifications
 - 6.1.1 Function of design engineering
 - 6.1.2 Design and building codes
 - 6.1.3 ASME Codes
- 6.2 Standards specific to leak testing
 - 6.2.1 National and International Standards (IRAM, ASTM, DIN, MIL)
 - 6.2.2 Interpretation of specification, codes and standards
- 6.3 Testing procedures
 - 6.3.1 Formulation of test procedures
 - 6.3.2 General and specific procedures
- 6.4 Safety in leak testing

SPECIFIC OBJECTIVES:

- 6.1 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;
- 6.2 Given the instructor's explanations, the student will be able to analyze, evaluate and apply leak testing according to national and international standards;
- 6.3 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.
- 6.4 Given the instructor's explanations, the student will be able to apply good safety practices in the application of leak testing.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Samples codes, standards, specifications and procedures

SUBJECT: 7. ORGANIZATION AND ADMINISTRATION OF NDT

CONTENTS:

7.1 Organization and administration of NDT

7.1.1 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.

7.1.2 Organization

- a) Equipment for work under way. Logistic provisions.
- b) Testing on production lines. Flow of materials. Work shifts.
- c) Maintenance of equipment and facilities.

7.1.3 Costs

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

7.1.4 Equipment selection and facility design

7.1.5 Operating procedures. Record-keeping

SPECIFIC OBJECTIVES:

7.1 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:

Blackboard
Transparencies
Course notes
Sample specifications and quotations
Sample procedures

INSPECTION METHOD: LEAK TESTING

LEVEL: 3

SUBJECT: 8. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL

CONTENTS:

8.1 Qualification and certification of personnel for NDT

8.1.1 National standards for the qualification and certification of personnel. Regional and international recommendations.

8.1.2 Training of personnel for NDT. Organization of courses and training in NDT methods.

8.1.3 Code of ethics

SPECIFIC OBJECTIVES:

8.1 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 systems;
- 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:

Blackboard
Transparencies
Course notes
Applicable standards and documents

VII. VISUAL TESTING (VT)

INSPECTION METHOD: VISUAL TESTING

S U B J E C T	HOURS OF TRAINING		
	LEVEL 1	LEVEL 2	LEVEL 3
1. GENERAL KNOWLEDGE	4	16	12
2. PHYSICAL PRINCIPLES OF THE TEST	6	8	4
3. VISION	2	4	4
4. EQUIPMENT AND ACCESSORIES	16	24	12
5. WORK PARAMETERS AND CONDITIONS	4	8	8
6. IMAGE RECORDING	4	12	16
7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES	4	8	8
8. QUALITY ASSURANCE AND STANDARDIZATION	-	-	6
9. ORGANIZATION AND ADMINISTRATION OF NDT	-	-	8
10. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL	-	-	2
T O T A L	40	80	80

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.1 Non-destructive testing of materials
 - 1.1.1 Definitions
 - 1.1.2 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 testing
 - d) Radiographic testing
 - e) Ultrasonic testing
 - f) Eddy current testing
 - g) Leak testing
 - 1.1.4 Limitations in the application of visual testing
- 1.2 Materials
 - 1.2.1 Properties of materials (metallic and non-metallic)
 - 1.2.2 Properties of metals
 - 1.2.3 Discontinuities
 - 1.2.4 Defects

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) define the nature of a 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Film (if available)
Course notes
Samples of various materials

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

- 1.3 Processes and defects
 - 1.3.1 Primary processes and related defects
 - a) Melting
 - b) Pouring
 - c) Cooling
 - 1.3.2 Processing and related defects
 - a) Casting
 - b) Welding
 - c) Forging
 - d) Rolling
 - e) Heat treatment
 - f) Machining
 - g) Plating
 - h) Other processes
 - 1.3.3 Service and related defects
 - a) Overload
 - b) Fatigue
 - c) Corrosion
 - d) Brittle fracture
 - e) Others

SPECIFIC OBJECTIVES:

- 1.3 Given the instructor's explanations, the student will be able to:
 - a) list the various metallurgical processes of fabrication and bonding;
 - b) describe the possible defects associated with each type of process;
 - c) describe the possible defects associated with the performance of a component in service.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Course notes
Samples of materials with typical defects

INSPECTION METHOD: VISUAL TESTING

LEVEL: 1

SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Nature of light

2.1.1 Electromagnetic radiations. Light spectra

2.1.2 Characteristics of light: intensity and colour

2.2 Sources of light

2.2.1 Illumination and luminance

2.2.2 Experimental laws of photometry

2.2.3 Units

2.3 Phenomena of 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 radiations;
- 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

Transparencies

Blackboard

Course notes

Various equipments for light emission

SUBJECT: 3. VISION

CONTENTS:

- 3. Vision
 - 3.1 Human eye
 - 3.1.1 Physical description and formation of image
 - 3.1.2 Perception of intensity and colour
 - 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 colour
 - 3.2.3 Vision defects

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 colour 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 colour perception;
 - b) enumerate vision defects.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures and guided discussions.

EQUIPMENT AND RESOURCES:

Slides
Transparencies
Blackboard
Course notes

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

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 T.V. systems

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including demonstration and student practical work.

EQUIPMENT AND RESOURCES:

Blackboard. Transparencies. 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 Direct and indirect observation techniques
- 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 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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, demonstrations and student practice.

EQUIPMENT AND RESOURCES:

Slides
Transparencies
Blackboard
Course notes
Jaeger charts
Sample pieces

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 Replica, different conditioning techniques for observation and special requirements for surface preparation

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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including demonstrations and student practice with different photographic cameras and films.

EQUIPMENT AND RESOURCES:

- Slides
- Transparencies
- Course notes
- Replica samples
- Blackboard
- Photographic cameras
- 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 Industrial safety standards
- 7.3 Instructions for the test
 - 7.3.1 Interpretation

SPECIFIC OBJECTIVES:

- 7.1 Given the instructor's explanations and various classification 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, the student will be able to describe the safety conditions under which the test with visual examination should be carried out.
- 7.3 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:

Blackboard
Codes, standards and specifications
Test samples
Course notes

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Basic principles of NDT

- 1.1.1 Definitions and methodology of applications of basic methods
- 1.1.2 Fields of application of common methods
- 1.1.3 Range and limitations of common methods
- 1.1.4 Limitations in the application of visual testing

1.2 Materials and defects

- 1.2.1 Structure of metals and alloys
- 1.2.2 Properties of materials (metallic and non-metallic)
- 1.2.3 Discontinuities and defects in metallic materials

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 material;
- b) describe the various types of discontinuities and defects, their sources and their classification.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Slides
Films
Blackboard
Course notes

INSPECTION METHOD: VISUAL 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
- 1.4 Materials in service
 - 1.4.1 Behaviour of materials in service
 - 1.4.2 Service conditions leading to defects and failures:
 - a) Corrosion
 - b) Fatigue
 - c) Wear
 - d) Overload
 - e) Brittle fracture
 - 1.4.3 Concepts of rupture development in metals

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 the basic mechanisms giving rise to defects when the component is in service;
 - b) describe the defects that could arise during service and the general significance of each.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Samples of materials and defects

INSPECTION METHOD: VISUAL TESTING

LEVEL: 2

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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:

- 1.5 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, guided discussion and review of examples.

EQUIPMENT AND RESOURCES:

Transparencies
Films
Slides
Blackboard
Course notes
Typical documents, i.e. codes

SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST

CONTENTS:

2.1 Nature of light

- 2.1.1 Electro-magnetic radiations. Light spectra. Infrared and ultraviolet radiation
- 2.1.2 Characteristics of light: intensity and colour. Characteristics of colour

2.2 Sources of light

- 2.2.1 Illumination. Luminous flux. Luminance
- 2.2.2 Experimental laws of photometry
- 2.2.3 Magnitudes and units
- 2.2.4 Measurement

2.3 Basic laws of the phenomena of reflection, refraction, dispersion, diffraction, absorption, and transmission of the 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 and 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:

Transparencies
Course notes
Blackboard

SUBJECT: 3. VISION

CONTENTS:

3. Vision

3.1 Human eye, the anatomical and physiological 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
- 3.2.5 Vision defects

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 colour;
- 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 colour.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lectures, development from student experience and guided discussion of examples with practical student involvement.

EQUIPMENT AND RESOURCES:

Transparencies
Course notes
Blackboard

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) Collimator, etc.

4.1.4 Types of illumination:

- a) Directional
- b) Diffused
- c) Secondary

4.1.5 Sources of non-visible radiation, ultraviolet, infrared, filters

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 repetitivity.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Course notes
Blackboard
Light sources
Auxiliary equipment
Visual aids
Light transmitting equipment
Sample pieces

INSPECTION METHOD: VISUAL TESTING

LEVEL: 2

SUBJECT: 4. EQUIPMENT AND ACCESSORIES

CONTENTS:

4.2 Visual aids

4.2.1 Lenses, prisms, mirrors, characteristics of construction

4.2.2 Optical systems, microscopes, telescopes, projectors, characteristics of construction

4.3 Image transmitting instruments

4.3.1 Instruments for optical transmission of images. Rigid and flexible endoscope, periscope. Basic principles and operations of image transmitting instruments and their construction characteristics.

4.3.2 Combination equipment for the transmission of images: optical equipment coupled to T.V. systems. Basic principles and operation of combination equipment, their construction characteristics, scope and limitations.

SPECIFIC OBJECTIVES:

4.2 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.

4.3 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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical use of equipment, development from student experience and guided discussions.

EQUIPMENT AND RESOURCES:

Transparencies
Course notes
Blackboard
Light sources
Ancillary equipment
Visual aids
Light transmitting equipment
Sample pieces

INSPECTION METHOD: VISUAL TESTING

LEVEL: 2

SUBJECT: 5. WORK PARAMETERS AND CONDITIONS

CONTENTS:

- 5.1 Surface preparation for examination
- 5.2 Observation techniques: direct and indirect
- 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, calibration of the examination using reference samples
- 5.5 Presentation of results to be used in analysis, documentation and filing

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.
- 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.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Transparencies
Course notes
Blackboard
Sample pieces
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

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:

Transparencies
Course notes
Blackboard
Photographic cameras
Replicas
Replica materials
Sample pieces
Photographic films

INSPECTION METHOD: VISUAL TESTING

LEVEL: 2

SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES

CONTENTS:

- 7.1 General knowledge 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

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 the various standards existing for the application of visual inspection;
 - c) prepare instructions for testing.
- 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.

METHODOLOGICAL STRATEGIES:

Instructor's explanations including lecture, guided discussion, practical exercise on interpretation of procedures and compilation of written instructions.

EQUIPMENT AND RESOURCES:

Blackboard
Codes
Standards (ASME, ASTM, DIN, API, BSI, COVENIN, JIS)
Formulae for data registration
Test procedures and examples of written instructions
Work pieces
Equipment and accessories

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

1.1 Technology of NDT

- 1.1.1 Definitions and methodology of applying NDT. Specific and distinctive characteristics of these methods.
- 1.1.2 Areas of NDT application. Quality control, maintenance. Defectology. Evaluation of properties.
- 1.1.3 Physical properties of the usual methods and their correlations with the examination requirements and defectology. Scope and limitations. Comparison of the most common methods.

SPECIFIC OBJECTIVES:

- 1.1 Given the instructor's explanations, the student will be able to:
 - a) discuss the methodology of applying NDT as well as the specific and distinctive characteristics of these methods;
 - b) determine the conditions for using NDT, evaluating its importance relative to the various types of problems and areas of application;
 - c) discuss the scope and the limitations of the various methods, correlating the physical principles with the test requirements, the defectology and the type of materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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 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 Plastic flow
- 1.2.10 Millwork, forging and power metallurgy
- 1.2.11 Machining fundamentals
- 1.2.12 Miscellaneous processes
- 1.2.13 Surface finishing

SPECIFIC OBJECTIVES:

- 1.2 Given the instructor's explanations, the student will be able to:
- a) describe, interpret, analyze and evaluate the defectology 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 bondings;
 - d) recognize various types of compound materials.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and presentation of cases for analysis and evaluation, guided discussion and solution of practical problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Slides
Tables of physical constants and properties of materials
Course notes and summaries
Films

INSPECTION METHOD: VISUAL TESTING

LEVEL: 3

SUBJECT: 1. GENERAL KNOWLEDGE

CONTENTS:

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

SPECIFIC OBJECTIVES:

1.3 Given the instructor's explanations, the student will be able to describe and properly handle units of the SI and other widely used systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

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.

SPECIFIC OBJECTIVES:

- 2.1 Given the instructor's explanations, the student will be able to:
- a) describe the properties;
 - 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:

Blackboard
Transparencies
Slides
Tables and drawings
Laboratory material to demonstrate physico-chemical principles
Course notes

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, colour 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.

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 values, types of lenses, prisms, mirrors and optical systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes

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 of light intensity (luximeters).

4.2 Visual aids

- 4.2.1 Lenses, prisms and mirrors
- 4.2.2 Compound lenses, stereoscopic loops, optical microscope, telescope and projectors

4.3 Image transmission

- 4.3.1 Fibre 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
- 4.3.3 T.V. systems. Block diagram.

SPECIFIC OBJECTIVES:

- 4.1 Given the instructor's explanations, the student will be able to:
 - a) explain the values of light source emitters according to the 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, lenses 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;
 - b) explain the combined system for image transmission;
 - c) explain the applications of T.V. systems.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical student work and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard. Transparencies. Course notes. Light sources. Visual aids. Image transmitting equipment. Sample pieces.

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 Parameter 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
- 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 Selection and specification of equipment for the test

SPECIFIC OBJECTIVES:

- 5. Given the instructor's explanations, the student will be able to:
 - a) establish all necessary preparations of surface for test;
 - b) establish all 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;
 - 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.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including lecture, practical student work and solution of problems.

EQUIPMENT AND RESOURCES:

Blackboard. Transparencies. Course notes. Sample pieces. Light sources. Jaeger and JIS charts. Reference blocks.

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

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.

METHODOLOGICAL STRATEGIES:

Instructor's demonstration including student practicals with different photographic cameras and film types.

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Course notes
Various types of cameras
Replicas
Replica materials
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
- 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:

Blackboard
Transparencies
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. QUALITY ASSURANCE AND STANDARDIZATION

SPECIFIC OBJECTIVES:

8.1 Quality assurance

- 8.1.1 Basic principles for the application of quality assurance
- 8.1.2 Organization of quality assurance. Quality manual. Quality control. Auditing of quality.
- 8.1.3 Management and control of quality assurance documentation, quality control of testing
- 8.1.4 Reports on testing, documentation systems

8.2 Standardization

- 8.2.1 Definition of standardization, principles of standards writing
- 8.2.2 Standards, codes, specifications and procedures, their uses
- 8.2.3 Reports and protocols

SPECIFIC OBJECTIVES:

- 8.1 Given the instructor's explanations, the student will be able to:
 - a) interpret and apply quality assurance procedures to the conducting 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.
- 8.2 Given the instructor's explanations, the student will be able to:
 - a) define standardization and discuss basic principles of standards writing;
 - b) discuss the benefits and applications of standards, codes, specifications and procedures.
 - c) write reports and keep records which meet the requirements of codes and standards.

METHODOLOGICAL STRATEGIES:

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

EQUIPMENT AND RESOURCES:

Blackboard
Transparencies
Quality assurance manuals
Films
Course notes
Typical documents

SUBJECT: 9. ORGANIZATION AND ADMINISTRATION OF NDT

CONTENTS:

9.1 Organization and administration of NDT

9.1.1 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

9.1.2 Organization

- a) Equipment for work under way. Logistic provisions
- b) Testing on production lines. Flow of materials. Work shifts
- c) Maintenance of equipment and facilities

9.1.3 Costs

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

9.1.4 Equipment selection and facility design

9.1.5 Operating procedures and record-keeping

SPECIFIC OBJECTIVES:

9.1 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 task 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:

Blackboard
Transparencies
Slides
Course notes
Sample specifications and quotations
Sample procedures

SUBJECT: 10. QUALIFICATION AND CERTIFICATION OF NDT PERSONNEL

CONTENTS:

- 10.1 Qualification and certification of personnel for NDT
 - 10.1.1 National standards for the qualification and certification of personnel. Regional and international recommendations.
 - 10.1.2 Training of personnel for NDT. Organization of courses and training in NDT methods.
 - 10.1.3 Code of ethics.

SPECIFIC OBJECTIVES:

- 10.1 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:

Blackboard
Transparencies
Applicable standards and documents
Course notes