



## International Certification in NDT (ICN)

*Training Syllabus for Certification of NDT Personnel  
as per ICN Certification Scheme*

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## **MAGNETIC PARTICLE TESTING**

# **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1**

## **SUBJECT: 1. GENERAL KNOWLEDGE**

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### 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 particle testing
      - d) Radiographic testing
      - e) Ultrasonic testing
      - f) Eddy current testing
    - 1.1.4 Limitations in the application of magnetic particle 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:

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- 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.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 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:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Transparencies  
Slides  
Films  
Course notes  
Samples of materials with typical defects

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

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**CONTENTS:**

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- 2.1 Electricity (General principles)
    - 2.1.1 Current, 2.1.2 Voltage, 2.1.3 Resistance
    - 2.1.4 Alternating current, 2.1.5 Direct current
  - 2.2 Magnetism (general principles)
    - 2.2.1 Magnetic poles; permanent magnets; temporary magnets
    - 2.2.2 Permeability
    - 2.2.3 Ferromagnetic, paramagnetic and diamagnetic materials
    - 2.2.4 Magnetic fields; lines of force; magnetic fields around the conductor
    - 2.2.5 Solenoid, electromagnet, 2.2.6 Magnetic flux, 2.2.7 Magnetization force
    - 2.2.8 Reluctance
    - 2.2.9 Hysteresis
  - 2.3 Visible and ultraviolet light
  - 2.4 Method of testing by magnetic particles
- 

**SPECIFIC OBJECTIVES:**

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

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

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**EQUIPMENT AND RESOURCES:**

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

# **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1**

## **SUBJECT: 3. METHODS AND TECHNIQUES**

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### CONTENTS:

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- 3.1 Methods of magnetization:
    - 3.1.1 Longitudinal
    - 3.1.2 Circular
    - 3.1.3 Vertical
  - 3.2 Magnetization techniques:
    - 3.2.1 Permanent magnets
    - 3.2.2 Electromagnets
    - 3.2.3 Coils
    - 3.2.4 Passage of current
    - 3.2.5 Central conductor
- 

### SPECIFIC OBJECTIVES:

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- 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.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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

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# **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1**

## **SUBJECT: 3. METHODS AND TECHNIQUES**

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### CONTENTS:

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- 3.3 Inspection techniques
  - 3.3.1 Remnant fields
  - 3.3.2 Continuous field
  - 3.3.3 Wet method
  - 3.3.4 Dry method
  - 3.3.5 Verification of magnetic fields
  - 3.3.6 Retentivity and coercive force
- 3.4 Demagnetization

- 3.4.1 Reasons for requiring demagnetization
  - 3.4.2 Demagnetization techniques and verification of remanant fields
- 

SPECIFIC OBJECTIVES:

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- 3.3 Given a background in the theory of magnetic particles and the means of application, the student will be able to:
    - a) distinguish between continuous and remnant magnetization and recognize the characteristics of the materials to be tested by each technique;
    - b) explain the difference between wet and dry methods and identify the characteristics of the particles to be used in each case;
    - c) verify the presence of a magnetic field.
  - 3.4 Given the explanations and demonstrations, the student will be able to:
    - a) describe the principles on which magnetization is based;
    - b) list the methods for demagnetization;
    - c) verify the remnant field.
    - d) explain the reasons for demagnetization
- 

METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 4.1 Knowledge of equipment:
  - 4.1.1 Permanent magnets
  - 4.1.2 Magnetic yokes
  - 4.1.3 Portable and stationary equipment
  - 4.1.4 Types of current
  - 4.1.5 Test current capacity
  - 4.1.6 Demagnetization equipment
- 4.2 Conditions of use:
  - 4.2.1 Equipment operation
  - 4.2.2 Equipment maintenance
  - 4.2.3 Safety
- 4.3 Accessories
  - 4.3.1 Contact points
  - 4.3.2 Vessels for checking inspection baths
  - 4.3.3 Field indicator (Berthold test piece)
  - 4.3.4 Calibration test pieces (JIS, ASTM, EN, MIL)
  - 4.3.5 Magnetic field measurement equipment
  - 4.3.6 Ultraviolet lamps
  - 4.3.7 Colored and fluorescent powders



#### 4.3.8 Color for increasing contrast

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##### SPECIFIC OBJECTIVES:

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- 4.1 Given a demonstration and explanation of the use of the equipment, the student will be able to:
  - a) recognize the main types of magnetization equipment;
  - b) identify the test capacity of each type of equipment;
  - c) identify the type of current used in each type of equipment;
  - d) identify the type of field generated by each type of equipment;
  - e) recognize demagnetization equipment.
- 4.2 Given a demonstration and explanation of equipment operations, the student will be able to:
  - a) recognize the different controls and identify their function;
  - b) operate the different types of equipment properly and safely;
  - c) state the maintenance procedures for each type of equipment.
- 4.3 Given a demonstration and explanation of accessories, the student will be able to:
  - a) distinguish between the types of contact points and their application;
  - b) recognize magnetic field measurement equipment, test pieces for calibration and control vessels for wet bath concentration;
  - c) recognize lamps for ultraviolet light and describe their proper use.

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##### METHODOLOGICAL STRATEGIES:

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

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##### EQUIPMENT AND RESOURCES:

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

### **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1**

### **SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES**

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##### CONTENTS:

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

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##### SPECIFIC OBJECTIVES:

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- 5.1 Given a set of written instructions, the student will be able to:
  - a) interpret the instructions correctly, perform the test on the appropriate work piece;
  - b) explain the differences between the techniques of wet and dry methods in relation to the conditions of application, size and form of the particles and the sensitivity of the test.
- 5.2 Given the demonstration and explanation and the liquids and particles, the student will be able to:
  - a) prepare colored and fluorescent particle suspensions in the appropriate concentrations;
  - b) compare these concentrations to standards or recommended practices.

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##### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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

### **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1**

### **SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES**

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#### CONTENTS:

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- 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:

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- 5.3 Given the necessary test conditions and equipment, the student will be able to:
    - a) determine the existence and direction of the magnetic field, using field indicators;
    - b) determine the existence of a remnant field;
    - c) perform demagnetization using various systems in each case, checking afterwards for the presence of a remnant field.
  - 5.4 Given the instructor's explanation and a selection of documents, the student will be able to recognize the different specifications and standards which govern the application of magnetic testing.
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#### METHODOLOGICAL STRATEGIES:

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Instructor's explanations and demonstrations guided discussion and practice.

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#### EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 1**

## **SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS**

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### CONTENTS:

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- 6.1 Presentation of results on test forms
  - 6.2 Recording of indications:
    - 6.2.1 To locate and identify them with reference to the test piece
    - 6.2.2 By photography
  - 6.3 Recognition of findings
    - 6.3.1 Indications of defects
    - 6.3.2 Spurious (false) indications
- 

### SPECIFIC OBJECTIVES:

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- 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;
    - 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.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2**

## **SUBJECT: 1. GENERAL KNOWLEDGE**

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### CONTENTS:

- 1.1 Basic principles of NDT
    - 1.1.1 Definitions and methodology of applications of basic methods: VT, PT, MT, RT, UT, ET,
    - 1.1.2 Fields of application of common methods
    - 1.1.3 Range and limitations of common methods, including the subject method
    - 1.1.4 New developments in NDT
    - 1.1.5 Responsibilities of levels of certification
  - 1.2 Materials
    - 1.2.1 Physical and mechanical properties of materials (metallic and non-metallic)
    - 1.2.2 Structures of metals and alloys
    - 1.2.3 Indications, discontinuities and defects
    - 1.2.4 In-service and manufacturing discontinuities
- 

### SPECIFIC OBJECTIVES:

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- 1.1 Given the instructor's explanations, the student will be able to:
    - a) define non-destructive testing;
    - b) describe the basic principles and the method of application of the common NDT methods;
    - c) discuss the best applications, limitations and problems relating to the use of each method.
  - 1.2 Given the instructor's explanations, the student will be able to:
    - a) describe the structure, physical and mechanical properties of metallic materials
    - b) describe the various types of discontinuities and defects, their sources and their classification.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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Transparencies  
Slides  
Films  
Writing board  
Course notes

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## CONTENTS:

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- 1.3 Processing and defects
    - 1.3.1 Primary processes and related defects
    - 1.3.2 Manufacturing processes and related defects
      - a) Casting processes and associated discontinuities, ingots, blooms, and billets; sand casting; centrifugal casting; investment casting
      - b) Wrought processes and associated discontinuities: forgings; rolled products; extruded products
      - c) Welding processes and associated discontinuities: submerged arc welding (SAW); shielded metal arc welding (SMAW); gas metal arc welding (GMAW); flux cored arc welding (FCAW); gas tungsten arc welding (GTAW); resistance welding; special welding processes — electron beam, electrogas, etc.
  - 1.4 Materials in service
    - 1.4.1 Behaviour of materials in service
    - 1.4.2 Service conditions leading to defects and failures, corrosion; creep; fatigue; wear; overload; brittle fracture, erosion, others
    - 1.4.3 Concepts of rupture development in metals
  - 1.5 Quality and standardization
    - 1.5.1 Definition of quality, quality control and standardization
    - 1.5.2 Development of a quality system
    - 1.5.3 Examination, testing and inspection
    - 1.5.4 Standards, codes, specifications and procedures
    - 1.5.5 Protocols, records and reports
- 

## SPECIFIC OBJECTIVES:

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- 1.3 Given the instructor's explanations, the student will be able to:
    - a) describe the common primary metallurgical processes and the related defects;
    - b) describe the common manufacturing processes and the related defects.
  - 1.4 Given the instructor's explanations, the student will be able to:
    - a) describe basic mechanisms giving rise to defects when the component is in service;
    - b) describe defects that could arise during service and the general significance of each.
  - 1.5 Given the instructor's explanations, the student will be able to:
    - a) describe the basic concepts of quality and standardization;
    - b) list the basic elements of a quality system;
    - c) explain the basic premise of administration of information in a quality system.
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## METHODOLOGICAL STRATEGIES:

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

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## EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2**

## **SUBJECT: 2. PHYSICAL PRINCIPLES AND FUNDAMENTALS OF MAGNETIC PARTICLE TESTING**

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### **CONTENTS:**

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- 2.1 Electricity
    - 2.1.1 Current, voltage and resistance; alternating current; direct current
  - 2.2 Magnetism; magnetic poles; permanent magnets; temporary magnets
    - 2.2.1 Ferro-, para-, and dia- magnetic materials
    - 2.2.2 Magnetic fields; lines of force; magnetic field around a conductor; solenoid; electromagnet; magnetic flux; magnetization force; reluctance; hysteresis
  - 2.3 Magnetic field characteristics; remanence; permeability; saturation; normal and tangential components of the magnetic field
  - 2.4 Terminology and abbreviations
  - 2.5 Electromagnetic waves
  - 2.6 Visible and ultraviolet light
- 

### **SPECIFIC OBJECTIVES:**

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- 2.1 Given the student's background knowledge and the instructor's explanation, the student will be able to:
    - a) explain the concepts of current, voltage and resistance;
    - b) relate these concepts to each other through Ohm's Law;
    - c) distinguish between alternating current, direct current and half wave rectified current, with specific reference to their applications in magnetic particle testing.
  - 2.2 Given the instructor's explanation and demonstrations, the student will be able to:
    - a) distinguish between ferromagnetic, paramagnetic and diamagnetic materials;
    - b) explain the concept of magnetism;
    - c) distinguish between temporary and permanent magnets;
    - d) explain the concepts of magnetic field, lines of force, magnetic poles and field distortion;
    - e) define magnetic flux, magnetization force, reluctance and capacitive force with respect to a given hysteresis curve;
    - f) illustrate magnetic field around a magnetic conductor, non-magnetic conductor and a solenoid, explain heat effects on magnetism;
    - g) explain material hardness vs. magnetic retention.
  - 2.3 Given the instructor's explanation and a specific hysteresis curve, the student will be able to determine the type of material to which it relates (high or low permeability).
  - 2.4 Given the student's general understanding and the instructor's explanations, the student will be able to:
    - a) list the terms relating to electricity, magnetism, electromagnetism and to testing by magnetic particles, indicating the related abbreviations;
    - b) determine the saturation point, describing its characteristics;
    - c) measure the variation in permeability along the curve;
    - d) identify the point of maximum permeability;
    - e) determine the normal and tangential components of a vectorial representation of the magnetic field.
  - 2.5 Given the student's background knowledge and the instructor's explanation, the student will be able to describe the characteristics of electromagnetic waves
  - 2.6 Given the instructor's explanations, the student will be able to:
    - a) distinguish between visible and ultraviolet light;
    - b) explain the concept of fluorescence.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 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:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

**INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2**

## **SUBJECT: 3. METHODS AND TECHNIQUES**

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### **CONTENTS:**

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- 3.4 Testing techniques
    - 3.4.1 For work pieces of differing alloy or, shape and condition
    - 3.4.2 With various types of current
    - 3.4.3 Field direction for some specific cases
    - 3.4.4 Appropriate field intensity
    - 3.4.5 Test sequences
    - 3.4.6 Safety precautions
  - 3.5 Miscellaneous field practices
    - 3.5.1 Preparation of the wet and dry suspension for coloured and fluorescent particles
    - 3.5.2 Techniques for checking field sensitivity
      - a) field indicators for calibration test pieces
      - b) work pieces for evaluating the sensitivity of the test
      - c) work pieces for evaluating magnetic particles
    - 3.5.3 Reasons for demagnetization
      - a) operating conditions
      - b) testing the effectiveness of demagnetization
- 

### **SPECIFIC OBJECTIVES:**

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- 3.4 Given work pieces of different composition and dimensions, the student will be able to:
    - a) select the most appropriate magnetization technique in each case, supporting this choice and specifying type of magnetization, method of applying the particles, type of current, field direction and calculation of current requirements
    - b) determine the logical sequence of tests;
    - c) carry out a magnetic test
    - d) be aware of the safety requirements
  - 3.5 Given the particles and the transport medium, the student will be able to:
    - a) obtain the correct concentration both for coloured and fluorescent magnetic particles, considering the reasons for the difference with respect to the percentage of particles to be used;
    - b) apply and compare the methods for checking sensitivity of a magnetic particle test, explaining the limitations of each;
    - c) evaluate the magnetic properties of the particles used in the test;
    - d) determine the conditions for and verification of demagnetization.
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### **METHODOLOGICAL STRATEGIES:**

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

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### **EQUIPMENT AND RESOURCES:**

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

## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2**



## **SUBJECT: 4. EQUIPMENT AND ACCESSORIES**

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### **CONTENTS:**

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- 4.1 Knowledge of equipment  
Permanent magnets; magnetic yoke; portable and stationary equipment; types of current and concepts of testing capacity; demagnetization equipment; maintenance and use of equipment
  - 4.2 Accessories  
Contact points; vessels for checking bath concentration; field indicators (Berthold test pieces); calibration pieces (JIS,ASTM,EN,MIL); magnetic field measurement equipment (Gaussmeter); ultraviolet lamps; colored and fluorescent powders; color for increasing contrast; morphology of the particles
  - 4.3 Selection of equipment appropriate to the nature of the test
  - 4.4 Special equipment : Portable equipment; stationary installations; automated equipment
- 

### **SPECIFIC OBJECTIVES:**

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- 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.
  - 4.2 Given the instructor's explanation and demonstration, the student will be able to:
    - a) recognize the types of contact points used, relating them to the work pieces in which they can be used;
    - b) use the various accessories correctly, including the vessels for checking bath concentration;
    - c) recognize the limitations on application of indicators and field measuring equipment;
    - d) compare coloured with fluorescent powders;
    - e) operate ultraviolet lamps properly, comparing the various types available;
    - f) determine the intensity requirements for ultraviolet lamps, describing how measurements are made.
  - 4.3 Given the instructor's explanation, demonstration and a particular work piece, the student will be able to select the most suitable equipment for performing the test, depending on the characteristics of the work piece and type of defect to be detected.
  - 4.4 Given the instructor's explanation and demonstration, the student will be able to compare portable and stationary equipment, identifying the advantages and limitations in each case and the conditions which must be met for using each type.
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### **METHODOLOGICAL STRATEGIES:**

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

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### **EQUIPMENT AND RESOURCES:**

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

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## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2**

## **SUBJECT: 5. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES**

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### CONTENTS:

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- 5.1 Interpretation of procedures for the application of tests using various techniques
  - 5.2 Composition of test procedures including instructions for various methods and techniques for use with work pieces of various materials and shapes, selection of equipment, field detection, intensity, type of current, selection of inspection medium, types of particles, sequence of testing, demagnetization
  - 5.3 Standards
    - 5.3.1 Qualification and certification of personnel
    - 5.3.2 Internal specifications and corresponding standards
    - 5.3.3 Codes and standards
- 

### SPECIFIC OBJECTIVES:

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- 5.1 Given the instructor's explanation and a written test procedure, the student will be able to perform the test properly, interpreting the indications resulting from the procedure.
  - 5.2 Given the instructor's explanation, the student will be able to:
    - a) interpret a procedure which would involve all the conditions under which the test must be carried out (equipment, current, field direction and intensity, type of particles);
    - b) determine the logical sequence for carrying out the test and the sequence for demagnetization;
    - c) compile instructions with sufficient detail for a level 1 operator to successfully carry out a magnetic particle test.
  - 5.3 Given the instructor's explanations and the appropriate documents, the student will be able to distinguish between codes and standards used in NDT, especially in magnetic particle testing, both for performing the test and for the qualification and certification of personnel conducting the test.
- 

### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2**

## **SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS**

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### CONTENTS:

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- 6.1 Preparation of reports on the testing
  - 6.2 Preparation and completion of the report form
  - 6.3 Documentation of the findings
    - a) to locate the indication within the component
    - b) by the use of sketching and photography
    - c) knowledge of documentation systems
    - d) management and control of complete documentation
-

#### SPECIFIC OBJECTIVES:

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- 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:

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

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#### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 2**

### **SUBJECT: 7. INTERPRETATION OF RESULTS, LIMITATIONS OF THE METHOD**

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#### CONTENTS:

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- 7.1 Presentation of results
  - 7.2 Interpretation of findings with reference to the manufacturing process:
    - a) evaluation of results according to the criteria of the procedure and specifications;
    - b) additional possibilities for making the results more conclusive
  - 7.3 Sensitivity and limitations
  - 7.4 Applications of magnetic testing and other methods of testing for surface and subsurface flaws
  - 7.5 Safety, implementation of industrial safety standards in facilities and equipment and in their operation; hazards of using toxic and inflammable materials; materials, equipment and accessories for the protection of persons and facilities
- 

#### SPECIFIC OBJECTIVES:

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

- 7.5 Given the instructor's explanations, the student will be able to:
- a) organize and administer the performance of tests with an NDT method with proper consideration of the safety of personnel and facilities;
  - b) organize the tasks of staff involved in NDT to ensure the operation is conducted safely and efficiently.

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METHODOLOGICAL STRATEGIES:  
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Instructor's presentation including lecture, demonstration, guided discussion and student practice.  
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EQUIPMENT AND RESOURCES:  
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Writing board, Power Point/Transparencies, Slides/Videos, course notes, test pieces of various dimensions, equipment and accessories for applying the test, written test procedures, codes and standards relating to the tests, codes and standards relating to NDT qualification and certification.

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

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CONTENTS: SEE BASIC LEVEL 3 SYLLABUS

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

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CONTENTS:

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- 2.1 Magnetism
    - 2.1.1 Theory and characteristics of the magnetic fields
    - 2.1.2 Demagnetizing effect
    - 2.1.3 Separation of the magnetic field
  - 2.2 Magnetic induction in materials
    - 2.2.1 Permeability in ferromagnetic and non-ferromagnetic materials
    - 2.2.2 Film effect
  - 2.3 Magnetic fields
    - 2.3.1 Generation of magnetic fields
    - 2.3.2 Basis for the calculation on of magnetization systems
  - 2.4 Measurement of
    - 2.4.1 Magnetic fields
    - 2.4.2 Electromagnetic fields
  - 2.5 Electromagnetic radiation
    - 2.5.1 Visible light
    - 2.5.2 Field radiation
    - 2.5.3 Physical concepts, measurements and equipment
    - 2.5.4 Conditions for visual observation
    - 2.5.5 Luminance thresholds
    - 2.5.6 Visual acuity
- 

SPECIFIC OBJECTIVES:

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

METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3**

## **SUBJECT: 3. METHODS AND TECHNIQUES**

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### CONTENTS:

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- 3.1 Magnetization
    - 3.1.1 Magnetization methods
    - 3.1.2 Magnetization techniques
      - a) Types of magnetic field application
      - b) Intensity and type of current
      - c) Combined magnetization
      - d) Individual cases
      - e) Incremental permeability
  - 3.2 Modes of operation
    - 3.2.1 Continuous field, conditions for application of the inspection medium.
    - 3.2.2 Remanant field
  - 3.3 Indicating medium
    - 3.3.1 Physical and chemical conditions necessary for the particles and suspension vehicles, wet and dry methods, fluorescent particles.
    - 3.3.2 Conditions for applying the indicating medium
- 

### SPECIFIC OBJECTIVES:

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

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

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### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3**

### **SUBJECT: 3. METHODS AND TECHNIQUES**

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#### CONTENTS:

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- 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
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#### SPECIFIC OBJECTIVES:

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

#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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

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## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3**

### **SUBJECT: 4. EQUIPMENT AND ACCESSORIES**

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#### CONTENTS:

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- 4.1 Equipment
  - 4.1.1 Selection for purchase
  - 4.1.2 Conditions of use and maintenance of equipment for magnetization and demagnetization, portable, permanently installed or automated
  - 4.1.3 Design basis of systems for testing

- 4.2 Accessories
  - 4.2.1 Design, selection and use of accessories for various testing techniques
  - 4.2.2 Field indicators
    - a) Analysis and comparison of the various field indicators (Berthold, ASME, BS, etc.)
    - b) Method of application and evaluation of application
  - 4.2.3 Instruments for magnetic field measurement, use of the Gaussmeter
  - 4.2.4 Various types of field radiation lamps and UV meters
- 4.3 Methods of indication
  - 4.3.1 Magnetizable particles
    - a) Chemical and physical characteristics
    - b) Morphology and dimensions
  - c) Various types: coloured and fluorescent
  - 4.3.2 Suspension vehicles for tests by wet methods
  - 4.3.3 Preparation and evaluation of indication media for test by wet and dry methods
- 4.4 AC and DC demagnetization equipment. Demagnetization equipment based on the oscillatory discharge of condensers.

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SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 5.1 Specifications of the examination, function of design engineering, design and building codes, ASME code.
- 5.2 Standards
  - 5.2.1 Specific standards for tests with magnetic particles (ASTM, JIS, BS, DIN)
  - 5.2.2 Interpretation of specifications, codes and standards
- 5.3 Procedures
  - 5.3.1 Formulation of test procedures
  - 5.3.2 General and specific procedures



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SPECIFIC OBJECTIVES:  
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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.

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

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

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

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CONTENTS:  
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- 6.1 Preparation of reports of the test
- 6.2 Preparation and completion of the report form
- 6.3 Documentation of the findings:
  - a) to locate the indication within the component
  - b) knowledge of documentation systems
  - c) management and control of complete documentation

-----  
SPECIFIC OBJECTIVES:  
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- 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.

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

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EQUIPMENT AND RESOURCES:  
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Transparencies, Power Point/Transparencies, Slides/Videos, Course notes, Test pieces of various dimensions, Equipment and accessories for applying the test, Written test procedures, codes and standards relating to the tests,

Photographic camera, Adhesive tape, Other recording media.

## **INSPECTION METHOD: MAGNETIC PARTICLE TESTING LEVEL: 3**

### **SUBJECT: 7. INTERPRETATION OF RESULTS, LIMITATIONS**

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#### CONTENTS:

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- 7.1 Presentation of results
  - 7.2 Thresholds of detection
    - a) evaluation of results according to the criteria of the procedure and specifications
    - b) additional possibilities for making the results more conclusive
  - 7.3 Interpretation of findings with reference to the manufacturing process
  - 7.4 Applications of magnetic particle testing and other methods of testing for surface and subsurface flaws
- 

#### SPECIFIC OBJECTIVES:

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

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

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#### EQUIPMENT AND RESOURCES:

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

## **PENETRANT TESTING**

# **INSPECTION METHOD: PENETRANT TESTING LEVEL: 1**

## **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
- 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 related defects
    - a) overload, b) fatigue, c) corrosion, d) brittle fracture, e) others

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### **SPECIFIC OBJECTIVES:**

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- 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.
- 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.

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### **METHODOLOGICAL STRATEGIES:**

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Instructor's presentation including lecture, demonstrations and guided discussions

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### **EQUIPMENT AND RESOURCES:**

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Writing board  
Transparencies  
Slides  
Film (if available)  
Course notes  
Samples of various materials with typical defects

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

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CONTENTS:

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- 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:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: PENETRANT TESTING LEVEL: 1**

### **SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST**

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#### CONTENTS:

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- 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:

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- 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.
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#### METHODOLOGICAL STRATEGIES:

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Instructor's explanations including lecture and guided discussion.

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#### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: PENETRANT TESTING LEVEL: 1**

### **SUBJECT: 3. PROCESSING**

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#### CONTENTS:

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- 3.1 Preparation of the specimen
  - 3.1.1 Treatment
  - 3.1.2 Identification
  - 3.1.3 Temperature

- 3.2 Cleaning prior to inspection
  - 3.2.1 Solvents
  - 3.2.2 Types and techniques of use
  - 3.2.3 Detergent solutions
  - 3.2.4 Chemical action solutions (acids, alkalis, removers)
  - 3.2.5 Inhibition and rinsing
  - 3.2.6 Use of ultrasonic agitation
  - 3.2.7 Mechanical media, brushing, grinding, sandblasting, etc.
  - 3.2.8 Conditions and limitations on their use
- 3.3 Drying
  - 3.3.1 Drying requirements
  - 3.3.2 Cold and hot air
  - 3.3.3 Temperature and time

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SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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Instructor's explanations including guided discussion and practical work.

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 3.4 Application of the penetrant; various modes of application; penetration time; temperature
- 3.5 Removal of excess penetrant
  - 3.5.1 Various methods of removal depending on type of penetrant; water-dispersible; water-soluble; solvent-soluble; post-emulsifiable; drying
- 3.6 Application of the developer
  - 3.6.1 Various techniques for application of the developer

### 3.6.2 Previous treatment of the developer

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#### SPECIFIC OBJECTIVES:

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- 3.4 Given the instructor's explanations, the student will be able to:
- a) describe the types of penetrant applications;
  - b) define penetration times in accordance with standards;
  - c) perform the correct application of a penetrant to a clean and dry work piece;
  - d) select the established penetration temperature and time, in accordance with penetration time and temperature written instructions.
- 3.5 Given the instructor's explanations, the student will be able to:
- a) list the systems for removal of excess penetrant, explaining the relationship with the type of penetrant used;
  - b) perform the removal of excess penetrant properly, applying the precautions and fulfilling the requirements necessary to avoid overwashing or insufficient removal, following a written procedure;
  - c) perform subsequent drying of the work piece if required by the procedure.
- 3.6 Given the instructor's explanations, the student will be able to:
- a) list the various types of developer application;
  - b) list the characteristics of a good developer;
  - c) explain the importance of developer distribution;
  - d) carry out the correct application of the developer, following a written procedure.
- 

#### METHODOLOGICAL STRATEGIES:

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Instructor's explanations including guided discussion and practical work.

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#### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: PENETRANT TESTING LEVEL: 1**

### **SUBJECT: 3. PROCESSING**

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#### CONTENTS:

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- 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:

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- 3.7 Given the instructor's explanations and written instructions, the student will be able to:
    - a) determine the conditions for observation, differentiating between them on the basis of whether the liquids are colored or fluorescent;
    - b) observe the indications following the observation sequence;
    - c) list the causes of false and/or irrelevant indications.
  - 3.8 Given the instructor's explanations, the student will be able to explain the procedure and importance of final cleaning.
  - 3.9 Given written instructions, the student will be able to note on the recording forms, the indications obtained in the test, showing graphically their location on a diagram of the work piece
- 

METHODOLOGICAL STRATEGIES:

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Instructor's explanations including guided discussion and practical work.

---

EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 4.1 Evaluation of the materials for testing
    - 4.1.1 Characteristic properties
    - 4.1.2 Behaviour properties
    - 4.1.3 Content of halogen, sulphur and other specific contaminants
  - 4.2 Cleaning equipment
    - 4.2.1 Ultrasonics
    - 4.2.2 Degreasing steam
  - 4.3 Pulverizers and aerosols
  - 4.4 Installations for processing by immersion
  - 4.5 Lighting, Measuring equipment and units
  - 4.6 Ultraviolet radiation lamps (black light)
    - 4.6.1 Efficiency types and characteristics
    - 4.6.2 Measurements of ultraviolet radiation intensity
    - 4.6.3 Units (micro watts/cm<sup>2</sup>)
- 

SPECIFIC OBJECTIVES:

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- 4.1 Given the instructor's explanations and a sample work piece, the student is able to:
  - a) list the parameters which are checked in order to ensure the suitability of the materials used in the test, describing how this check is performed;
  - b) compare the sensitivity of the test, carrying out every stage.
- 4.2 Given the systems of cleaning, the student will be able to recognize their proper state and operation.
- 4.3 Given various types of pulverizers and aerosols, the student will be able to test the effectiveness of the system and proper condition of the equipment.

- 4.4 Given the instructor's explanations, the student will be able to:
  - a) distinguish between portable equipment and stationary equipment for immersion;
  - b) recognize each of the sections of the equipment and its use.
- 4.5 Given the instructor's explanations, the student will be able to:
  - a) recognize various types of lighting equipment;
  - b) explain positioning and measurement.
- 4.6 Given various ultraviolet lamps, the student will be able to:
  - a) recognize the type of lamp and its efficiency characteristics.
  - b) measure the intensity of ultraviolet radiation, using a suitable measuring instrument.

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METHODOLOGICAL STRATEGIES:

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Instructor's explanations including guided discussion and practical work.

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 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:

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- 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:

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Instructor's explanations including guided discussion and practical workshop.

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EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: PENETRANT TESTING LEVEL: 1**

## **SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS**

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### CONTENTS:

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- 6.1 Presentation of results on test forms
  - 6.2 Recording of indications
    - 6.2.1 To locate and identify them with reference to the test piece
    - 6.2.2 By photography
  - 6.3 Recognition of findings
    - 6.3.1 Indications of defects
    - 6.3.2 Spurious (false) indications
- 

### SPECIFIC OBJECTIVES:

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

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

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### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

- 1.1 Basic principles of NDT
    - 1.1.1 Definitions and methodology of applications of basic methods: VT, PT, MT, RT, UT, ET, LT
    - 1.1.2 Fields of application of common methods
    - 1.1.3 Range and limitations of common methods, including the subject method
    - 1.1.4 New developments in NDT
    - 1.1.5 Responsibilities of levels of certification
  - 1.2 Materials
    - 1.2.1 Physical and mechanical properties of materials (metallic and non-metallic)
    - 1.2.2 Structures of metals and alloys
    - 1.2.3 Indications, discontinuities and defects
    - 1.2.4 In-service and manufacturing discontinuities
- 

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

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CONTENTS:

- 1.3 Processing and defects
    - 1.3.1 Primary processes and related defects
    - 1.3.2 Manufacturing processes and related defects:
      - a) Casting processes and associated discontinuities: Ingots, blooms, and billets; Sand casting; Centrifugal casting; Investment casting
      - b) Wrought processes and associated discontinuities: forgings; rolled products; extruded products
      - c) Welding processes and associated discontinuities: submerged arc welding (SAW); shielded metal arc welding (SMAW); gas metal arc welding (GMAW); flux cored arc welding (FCAW); gas tungsten arc welding (GTAW); resistance welding; special welding processes — electron beam, electrogas etc.
  - 1.4 Materials in service
    - 1.4.1 Behaviour of materials in service
    - 1.4.2 Service conditions leading to defects and failures: corrosion; creep; fatigue; wear; overload; brittle fracture, erosion, others
    - 1.4.3 Concepts of rupture development in metals
  - 1.5 Quality and standardization
    - 1.5.1 Definition of quality, quality control and standardization
    - 1.5.2 Development of a quality system
    - 1.5.3 Examination, testing and inspection
    - 1.5.4 Standards, codes, specifications and procedures
    - 1.5.5 Protocols, records and reports
- 

SPECIFIC OBJECTIVES:

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

- a) describe basic mechanisms giving rise to defects when the component is in service;
  - b) describe defects that could arise during service and the general significance of each.
- 1 5 Given the instructor's explanations, the student will be able to:
- a) describe the basic concepts of quality and standardization;
  - b) list the basic elements of a quality system;
  - c) explain the basic premise of administration of information in a quality system.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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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 Behavior 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

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SPECIFIC OBJECTIVES:

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

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METHODOLOGICAL STRATEGIES:

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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.

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: PENETRANT TESTING LEVEL: 2**

### **SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST**

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#### CONTENTS:

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- 2.5 Luminous and ultraviolet spectrum
    - 2.5.1 Color and fluorescence
    - 2.5.2 Colors
    - 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:

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- 2.5 Given the instructor's explanations, the student will be able to:
    - a) explain the mechanism of development and the behavior of development powders in the dry state and in liquid suspension;
    - b) explain the phenomena of colour and fluorescence;
    - c) describe the behavior of fluorescent dyes and pigments in solutions.
  - 2.6 Given the instructor's explanations, the student will be able to list the basic components of liquid penetrants and describe the influence of formulation on their behavior.
  - 2.7 Given the instructor's explanations, the student will be able to:
    - a) list the various types of removers and explain their behavior;
    - b) list the various types of emulsifiers and explain the mechanisms of emulsification.
  - 2.8 Given the instructor's explanations, the student will be able to explain the composition, granulometry and behavior of the developers.
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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 3.1 Preparation of the work piece, treatment, identification and protection of the areas not to be examined
  - 3.2 Cleaning prior to inspection
    - 3.2.1 Various techniques applicable
      - a) Solvents
      - b) Vapour degreasing
      - c) Detergent solutions
      - d) Solutions having a chemical action (acid and alkali removers, etc.)
      - e) Ultrasonic cleaning
      - f) Mechanical means (grinding, sandblasting, brushing)
    - 3.2.2 Conditions and limitations of the different cleaning techniques
    - 3.2.3 Comparison of the effectiveness of the different techniques in relation to the surface state of the specimen
  - 3.3 Conditions and requirements for the different drying stages
    - 3.3.1 Use of cold and hot air
    - 3.3.2 Temperature and time
- 

SPECIFIC OBJECTIVES:

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

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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.

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 3.4 Inspection process
  - 3.4.1 Application of the penetrating agent
    - a) application techniques,
    - b) temperature,
    - c) penetration time
  - 3.4.2 Removal of excess penetrating agent
    - a) various methods of removal depending on type of penetrant, water-dispersable, water-soluble, solvent-soluble, post emulsifiable;
    - b) conditions for the application of lipophilic and hydrophilic emulsifiers;
    - c) drying;
    - d) requirements and precautions in the removal stage
  - 3.4.3 Application of the developer
    - a) various techniques,
    - b) previous treatment of the developer
- 3.5 Observation of the findings
  - 3.5.1 Lighting conditions for coloured liquids and UV radiation for fluorescent liquids
  - 3.5.2 Sequence and time of observation
  - 3.5.3 Interpretation of the findings and identification of the type of defects
  - 3.5.4 Spurious or non-relevant findings
- 3.6 Recording of findings
  - 3.6.1 Test forms
  - 3.6.2 Localization schemes
  - 3.6.3 Transfer of findings
  - 3.6.4 Photographic techniques
  - 3.6.5 Writing reports
- 3.7 Testing techniques for detection of leaks by means of liquid penetrants

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SPECIFIC OBJECTIVES:

- 3.4 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to explain the application of liquid penetrants to carry out a valid inspection.
- 3.5 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to describe the conditions required for the observation, interpretation and recording of the indications.
- 3.6 Given the instructor's explanations and performance of the appropriate practical exercises, the student will be able to interpret, evaluate and record the findings of the test in accordance with the written procedures.
- 3.7 Given the instructor's presentation, the student will be able to explain liquid penetrant methods for leak detection.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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



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

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CONTENTS:

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- 4.1 Evaluation of the materials used in the test
    - 4.1.1 Penetrating agents
      - a) Characteristic properties, viscosity, density, surface tension, ignition point, halogen and sulphur content, color, fluorescence
      - b) Behavior, drop expansion, wash ability, corrosion, preservation, stability under light and UV radiation
    - 4.1.2 Removers
      - a) Characteristic properties and behavior
      - b) Granulometry and apparent volume
      - c) Sedimentation and compaction
    - 4.1.3 Emulsifiers characteristic properties and behavior
    - 4.1.4 Developers
      - a) Characteristic properties and behavior
      - b) Granulometry and apparent volume
      - c) Sedimentation
      - d) Evaluation of processes
      - e) Use of standardized work pieces
  - 4.2 Cleaning equipment
    - 4.2.1 Degreasing vapor
    - 4.2.2 Ultrasonic
- 

SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including demonstrations and guided discussion.

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 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 light meters
  - 4.5.1 Ultraviolet radiation sources (black light) and meters for measuring UV radiation intensity
  - 4.5.2 Checking the efficiency of ultraviolet lamps
  - 4.5.3 Cabinets for observation of fluorescent penetrating liquids
- 4.6 Standardized work pieces for evaluating processes and qualifying procedures
  - 4.6.1 ASTM, MIL, JIS, IRAM test pieces
  - 4.6.2 Non-standardized test pieces for checking penetrability
  - 4.6.3 Equipment for checking fluorescence and efficiency of UV lamps

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SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including demonstrations and guided discussion.

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 5.1 Standards applicable to liquid penetrant testing
  - 5.1.1 Test methods
  - 5.1.2 Materials for the test (ASTM, DIN, MIL, IRAM)
  - 5.1.3 ASME code
- 5.2 Test specifications and procedures
  - 5.2.1 Interpretation
  - 5.2.2 Formulation of instructions for the test
- 5.3 National standards for liquid penetrant testing and testing personnel
  - a) quality control of the test and procedure for its administration,
  - b) quality assurance requirements
- 5.4 Problems of industrial safety in the use of chemical and inflammable products
  - 5.4.1 Applicable safety standards

- 5.4.2 Safety conditions required for the use of UV light
- 5.4.3 Drafting of safety instructions for the personnel involved
- 5.4.4 Safety factors applicable to the test
- 5.4.5 Environmental protection

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SPECIFIC OBJECTIVES:

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- 5.1 Given the instructor's explanations and the performance of practical exercises, the student will be able to:
  - a) state classification systems of the techniques for application of liquid penetrants according to the standards in force,
  - b) explain the criteria for application of liquid penetrants according to the standards in force;
- 5.2 Given the instructor's explanations and the performance of practical exercises, the student will be able to:
  - a) interpret general and specific test procedures for liquid penetrants;
  - b) develop test instructions for level 1;
  - c) formulate the information required for documenting the test and presenting reports.
- 5.3 Given the instructor's explanations and the performance of practical exercises, the student will be able to recognize the qualification and certification standard for NDT personnel in force in his respective country;
- 5.4 Given the instructor's explanations and discussion of the subjects, the student will be able to:
  - a) describe the risks inherent in the use of chemical and inflammable products;
  - b) describe the risks involved in using UV radiation;
  - c) list the applicable safety standards;
  - d) prepare safety instructions for application of the test;
  - e) describe the risks of environmental contamination

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

**INSPECTION METHOD: PENETRANT TESTING LEVEL: 2**  
**SUBJECT: 6. INTERPRETATION OF RESULTS, LIMITATION**

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CONTENTS:

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- 7.1 Presentation of results
- 7.2 Interpretation of findings with reference to the manufacturing process
  - a) evaluation of results according to the criteria of the procedure and specifications
  - b) additional possibilities for making the results more conclusive
- 7.3 Sensitivity and limitations
- 7.4 Applications of penetrant testing and other methods of testing for surface flaws

7.5 Safety: Implementation of industrial safety standards in facilities and equipment and in their operation; hazards of using toxic and inflammable materials; materials, equipment and accessories for the protection of persons and facilities

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SPECIFIC OBJECTIVES:

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

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS: SEE BASIC LEVEL 3 SYLLABUS

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

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CONTENTS:

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- 2.1 Review of physical, chemical and physico-chemical principles for applying the method. Liquid- solid interface phenomena
  - 2.2 Solutions and dispersions, solvents and dispersing agents, lipophilic and hydrophilic emulsifiers
  - 2.3 Physicochemical mechanisms determining penetration, emulsification and developing
  - 2.4 General spectrum of electromagnetic radiation, luminaries spectrum, ultraviolet and infra- red radiation, wood radiation (black light), measurement and units
  - 2.5 Color and fluorescence, light absorption phenomena, Beer's law, absorption spectrometry, fluorescent emission spectra
  - 2.5 Mechanism of vision, conditions for visual observations, perception of light, colour and contrast, systems of weighing units and thresholds
- 

SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: PENETRANT TESTING LEVEL: 3**

### **SUBJECT: 3. PROCESSING**

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#### CONTENTS:

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- 3.1 Selection of the test techniques in relation to the type of specimen and design specifications
  - 3.2 Treatment and preparation of the specimen
    - 3.2.1 Protection of areas not being examined
    - 3.2.2 Selection of techniques for preparation and preliminary cleaning
    - 3.2.3 Systems of cleaning, design and monitoring;
    - 3.2.4 Intermediate drying, conditions and requirements for the various techniques
  - 3.3 Application of the penetrating agent
    - 3.3.1 Comparison of the various techniques
    - 3.3.2 Determination of special conditions depending on the examination requirements
    - 3.3.3 Acceptable temperature intervals
    - 3.3.4 Special cases of high and low temperature
    - 3.3.5 Penetration time
  - 3.4 Removal of the excess penetrating agent
    - 3.4.1 Removal techniques for the various systems
    - 3.4.2 Design and monitoring of the removal stage
    - 3.4.3 Post- emulsification
    - 3.4.4 Lipophilic and hydrophilic emulsifiers
  - 3.5 Techniques of development
    - 3.5.1 Treatment of the specimens prior to development
    - 3.5.2 Various types of developer
    - 3.5.3 Treatment, selection and control
  - 3.6 Observation of the indications
    - 3.6.1 Lighting conditions and Wood radiation requirements, depending on the applicable techniques and characteristics of the specimen;
    - 3.6.2 Method, time and sequence of the observations;
    - 3.6.3 Methods and media for recording indications
- 

#### SPECIFIC OBJECTIVES:

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- 3.1 Given the instructor's explanations, the student will be able to select test techniques in accordance with the design specifications and the state and type of specimen to be tested,
  - 3.2 Given the instructor's explanations, the student will be able to analyze, evaluate and determine the requirements for the identification, treatment and pre-cleaning of the specimens to be tested;
  - 3.3 Given the instructor's explanations, the student will be able to evaluate, settle and apply various methods of applying the penetrant to specimens of different configurations.
  - 3.4 Given the instructor's explanations, the student will be able to select and evaluate effective penetrant removal systems.
  - 3.5 Given the instructor's explanations, the student will be able to select and evaluate various developer systems.
  - 3.6 Given the instructor's explanations, the student will be able to define and evaluate the necessary conditions for proper inspection and adequate interpretation of results.
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#### METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 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:

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- 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:

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

---

EQUIPMENT AND RESOURCES:

---

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

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

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CONTENTS:

- 
- 4.1 Formulation of the penetrating liquids used in various techniques
    - 4.1.1 Types of dyes and pigments
    - 4.1.2 Penetrants for prior cleaning and for removal
    - 4.1.3 Solvents
    - 4.1.4 Lipophilic and hydrophilic emulsifiers
    - 4.1.5 Characteristics and properties
    - 4.1.6 Developers
    - 4.1.7 Physicochemical properties and characteristics
    - 4.1.8 Form of presentation and use
  - 4.2 Evaluation of materials
    - 4.2.1 Characteristic properties and behavior
    - 4.2.2 Test methods for the evaluation
    - 4.2.3 Standardized test pieces (ASTM, MIL, JIS, IRAM) for evaluation of processes and rating of procedures
  - 4.3 Equipment and accessories applicable to the test under way
    - 4.3.1 Pulverization systems and equipment for liquid as
    - 4.3.2 Isothermic and adiabatic compressors
    - 4.3.3 Electrostatic pulverizers
    - 4.3.4 Stationary installations for manual and automatic processing.
  - 4.4 Lighting for direct observation and ultraviolet radiation sources
    - 4.4.1 Measuring instruments
    - 4.4.2 Devices for evaluating pigment fluorescence and efficiency of ultraviolet lamps
- 

#### SPECIFIC OBJECTIVES:

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- 4.1 Given the instructor's explanations and performance of the practical work and calculations, the student will be able to analyze, evaluate and select the various economically viable processes, depending on the requirements of the examination in question and the test conditions.
  - 4.2 Given the instructor's explanations and performance of the practical work and calculations, the student will be able to: a) determine the requirements of testing and analysis applicable to control of the materials used in the test; b) select the type of work piece for evaluation suited to the processes to be used; c) determine suitable methods for rating the processes to be used.
  - 4.3 Given the instructor's explanations and performance of the practical work and calculations, the student will be able to: a) evaluate, select and apply correctly the equipment and accessories corresponding to the application of the specific test techniques involved; c) select, install and adjust test installations for manual 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.
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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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



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

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CONTENTS:

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- 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:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: PENETRANT TESTING LEVEL: 3**

### **SUBJECT: 6. PRESENTATION AND RECORDING OF RESULTS**

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#### CONTENTS:

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- 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:

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- 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:

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

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#### EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: PENETRANT TESTING LEVEL: 3**

## **SUBJECT: 7. INTERPRETATION OF RESULTS, LIMITATIONS**

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### CONTENTS:

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- 7.1 Presentation of results
  - 7.2 Thresholds of detection:
    - a) evaluation of results according to the criteria of the procedure and specifications
    - b) additional possibilities for making the results more conclusive
  - 7.3 Interpretation of findings with reference to the manufacturing process
  - 7.4 Applications of penetrant testing and other methods of testing for surface and subsurface flaws
- 

### SPECIFIC OBJECTIVES:

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

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

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### EQUIPMENT AND RESOURCES:

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

# **RADIOGRAPHIC TESTING**

# **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1**

## **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:

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- 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.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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Blackboard, transparencies, slides, film (if available),  
Course notes, samples of various materials

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

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**CONTENTS:**

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- 1.3 Processes and defects
    - 1.3.1 Primary processes and related defects
      - a) Melting
      - b) Pouring
      - c) Cooling
    - 2.1 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) Creep
      - e) Brittle fracture
      - f) Others
- 

**SPECIFIC OBJECTIVES:**

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- 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:**

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

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**EQUIPMENT AND RESOURCES:**

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Transparencies, slides, films  
Course notes  
Samples of materials with typical defects

# **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1**

## **SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST**

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### CONTENTS

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- 2.1 Penetrating radiation
    - 2.1.1 Atomic Structure
    - 2.1.2 Isotope and radioisotopes
    - 2.1.3 Artificial and natural radioisotopes
    - 2.1.4 Electromagnetic spectrum
    - 2.1.5 Particulate and electromagnetic radiation
    - 2.1.6 X rays and gamma rays
    - 2.1.7 Wavelength and energy
    - 2.1.8 X ray and gamma ray spectra
    - 2.1.9 KVp, KVc, KeV, MeV
    - 2.1.10 Inverse square Law for distance/intensity
    - 2.1.11 General properties of propagation of penetrating radiation
    - 2.1.12 Units related to penetrating radiation
  - 2.2 Principles of radioactive decay
    - 2.2.1 Definition of radioactivity
    - 2.2.2 Unit of radioactivity (Curie and Becquerel)
    - 2.2.3 Specific activity
    - 2.2.4 Decay equation
    - 2.2.5 Half-life
- 

### SPECIFIC OBJECTIVES:

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- 2.1 Given the instructor's explanations and a type of radiation, the student will be able to:
    - a) List its properties;
    - b) Explain the characteristics of the spectrum;
    - c) Calculate the variation in intensity of the radiation with distance;
    - d) Recognize the basic units applied in radiographic testing.
  - 2.2 Given the instructor's explanations, the student will be able to:
    - a) Distinguish between radioactive decay, radioactivity and half -life;
    - b) Explain the difference between artificial and natural radioactive sources.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 2.3 Interaction of radiation with matter
    - 2.3.1 Photoelectric effect, Compton effect, pair production
    - 2.3.2 Absorption coefficient, half value layer (HVL), tenth value layer
    - 2.3.4 Ion and ionization
  - 2.4 Detection of ionizing radiation
    - 2.4.1 Ionization Chamber
    - 2.4.2 Geiger Muller Counter
    - 2.4.3 Scintillation detector
    - 2.4.4 Proportional counter
- 

SPECIFIC OBJECTIVES:

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- 2.3 Given the instructor's explanations, the student will be able to:
    - a) compare the different processes of interaction of radiation with matter;
    - b) relate the attenuation of radiation to half-thickness.
  - 2.4 Given the instructor's explanations, the student will be able to:
    - a) recognize the different systems of measuring ionization
    - b) distinguish between the various radiations magnitudes;
    - c) distinguish between types of radiation measuring instruments, describing their proper application.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 3.1 X ray equipment
  - 3.1.1 Generation of x-ray (source of electron, acceleration of free electrons and target material)
  - 3.1.2 Stationary and mobile units
  - 3.1.3 X ray generators and tubes (glass and metal ceramic), target material and characteristics, configuration, focus, heat dissipation
  - 3.1.4 Design of tubes (standard tube; rod anode tube; short anode tube)..
  - 3.1.5 X-ray tube head, power source
  - 3.1.6 X-ray control panel (tube voltage, tube current, exposure time)
  - 3.1.7 Cooling (gas, water, oil)
  - 3.1.8 X-ray quality and quantity



- 3.1.9 Accessories
  - 3.2 Gamma ray sources
    - 3.2.1 Gamma ray spectrum
    - 3.2.2 Common radiography sources (source size, half-life, energy, activities)
    - 3.2.3 Radiography source assembly
    - 3.2.4 Types of gamma projector, shielding, collimators
    - 3.2.5 Handling of radiography projector
- 

SPECIFIC OBJECTIVES:

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- 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:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 4.1 Photographic recording (film for X ray and gamma ray radiography)
    - 4.1.1 Film construction (base layer, emulsion layer and protective layer)
    - 4.1.2 Radiography image formation
    - 4.1.3 Film characteristics (film density, film speed, film contrast, film definition)
    - 4.1.4 Characteristic curves, radiographic quality
    - 4.1.5 Film Screen-Lead screens (intensifying effect; filtering effect; film to screen contact)
    - 4.1.6 Fluorescent screen
  - 4.2 Non-photographic recording
    - 4.2.1 Fundamental of digital image processing
    - 4.2.2 Description of the fluoroscopic test
- 

SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 5.1 Parameters and work conditions
  - 5.1.2 Geometric principles of image formation, umbra and penumbra
  - 5.1.3 Relation between geometrical unsharpness with focal spot size, source to film distance, source to object distance, object to film distance
  - 5.1.4 Image density, factors affecting it
  - 5.1.5 Image quality, sensitivity, and radiography contrast and radiography definition
  - 5.1.6 Scattered radiation, types, causes, and control
  - 5.1.7 Use of screens, masks, filters
  - 5.1.8 Image quality indicators (IQI) according to various standards, characteristics, types and placement
  - 5.1.9 Radiography exposure and factors governing it
  - 5.1.10 Exposure charts for X-rays and gamma rays
  - 5.1.11 exposure calculations
- 

SPECIFIC OBJECTIVES:

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

METHODOLOGICAL STRATEGIES:

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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.

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EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 1**

## **SUBJECT: 5. WORK PARAMETERS AND CONDITIONS**

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### CONTENTS:

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- 5.2 Care in the handling and conservation of film
    - 5.2.1 Film handling
    - 5.2.2 Storage of processed and unprocessed films
    - 5.2.3 Loading and unloading film
    - 5.2.4 Darkroom layout, equipment, and chemicals,
    - 5.2.5 Processing of film
    - 5.2.6 Unsatisfactory radiographs and misleading images
  - 5.3 Viewing of radiographs
    - 5.3.1 Eye Adaptation
    - 5.3.2 Viewing requirement
    - 5.3.3 Viewing room lighting requirement
    - 5.3.4 Viewing accessories, viewer, densitometer, light-meter
  - 5.4 Evaluation of radiograph quality:
    - 5.4.1 Presence of artifacts
    - 5.4.2 Density measurement
    - 5.4.3 Location marker
    - 5.4.4 Film identification marker
    - 5.4.5 Image quality indicators (types, designation, placement, visible wire/hole)
- 

### SPECIFIC OBJECTIVES:

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- 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:

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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.

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### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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

SPECIFIC OBJECTIVES:

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

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 7.1 Influence of properties of the material
  - 7.2 Exposure techniques according to the geometry of the object
    - 7.2.1 Single wall/single image
    - 7.2.2 Double wall/single image
    - 7.2.3 Double wall/double image
    - 7.2.4 Panoramic and directional exposure
    - 7.2.5 Thickness compensation
    - 7.2.6 Masks
- 

SPECIFIC OBJECTIVES:

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- 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

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 8.1 Codes, standards, specifications and procedures
    - 8.1.1 General knowledge of codes and standards as applied to radiographic testing
    - 8.1.2 General knowledge of specifications and procedures for radiographic testing
    - 8.1.3 Examples of codes and standards related to industrial radiography inspection
  - 8.2 Written instruction
    - 8.2.1 Content of written instruction
    - 8.2.2 Performance of tests in accordance with written instructions
  - 8.3 Identification of radiographs and recording of tests
- 

SPECIFIC OBJECTIVES:

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- 8.1 Given the instructor's explanations, the student will be able to:
    - a) explain the significance and application of codes, standards, specifications and procedures;
    - b) recognize the structure of codes and standards;
    - c) recognize the different standards existing with respect to the application of radiographic testing;
    - d) recognize the difference between standards, specifications and procedures.
  - 8.2 Given the instructor's explanations and written instructions, the student will be able to carry out practical radiographic work, following the relevant instructions and noting the operational conditions of the test on data forms.
  - 8.3 Given the instructor's explanations and various practical examples of performing radiographs in plants, the student will be able to describe a system of codified recording, correctly identifying the radiographs.
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METHODOLOGICAL STRATEGIES

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 9.1 Radiation quantity and units
  - 9.1.1 Exposure
  - 9.1.2 Absorbed dose
  - 9.1.3 Equivalent dose

- 9.1.4 Dose limit for workers and publics
- 9.2 Dangers of excessive Biological effects of exposure to X rays and gamma rays
  - 9.2.1 Source of radiation exposure to human being (natural, manmade and accidental)
  - 9.2.2 Acute and chronic exposure
  - 9.2.3 Somatic and genetic effects
  - 9.2.4 Stochastic and no stochastic effect
  - 9.2.5 Wearing of monitoring Film badges
  - 9.2.6 Reading of pocket dosimeters and recording its daily readings
  - 9.2.7 Thermoluminiscent dosimeter (TLD)
- 9.3 Method of controlling external exposure
  - 9.3.1 Time
  - 9.3.2 Distance
  - 9.3.3 Shielding

---

SPECIFIC OBJECTIVES:

- 9.1 Given the instructor's explanations, the student will be able to recognize the dangers of excessive exposure to X-rays or gamma rays.
- 9.2 Given the instructor's explanations and radiation protection standards, the student will be able to recognize the maximum permissible radiation doses and their effects on the organism.
- 9.3 Given the instructor's explanations, the student will be able to relate the exposure dose to variations in time, distance or shielding.
- 9.4 Given the instructor's explanations, the student will be able to understand the units used.

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METHODOLOGICAL STRATEGIES

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

- 9.4 Work place monitoring
  - 9.4.1 Purpose of monitoring
  - 9.4.2 Radiation survey-meter, reading and interpreting meter indications
  - 9.4.3 Application of radiation survey-meter (e.g confirming source inside the projector etc)
  - 9.4.4 Recording radiation survey results
  - 9.4.5 Calibration frequency, calibration expiration action, battery check importance
- 9.5 Radiographic works in exposure room
  - 9.5.1 Preparation prior to commencement of works (safety equipment and accessories)
  - 9.5.2 Safety requirement for exposure rooms (dose reading, warning light)
  - 9.5.3 Area monitoring before, during and after radiography works
- 9.6 Radiography works at open and semi open sites
  - 9.6.1 Preparation prior to commencement of works (safety equipment and accessories)
  - 9.6.2 Establishment of restricted area; posting and surveillance of restricted areas,
  - 9.6.3 Use of time, distance, and shielding to reduce personnel radiation exposure,

- 9.6.4 Use of collimators to reduce personnel exposure
- 9.6.5 Use of "source changers" for gamma ray sources
- 9.7 Transportation of exposure devices and sources
  - 9.7.1 Transportation within premises
  - 9.7.2 Transportation outside premises
  - 9.7.3 Transport index
  - 9.7.4 Labeling
- 9.8 Storage of radiography equipment
  - 9.8.1 Vehicle storage
  - 9.8.2 Storage for x-ray machine
  - 9.8.3 Storage of gamma ray exposure device
- 9.9 Emergency procedures
  - 9.9.1 Equipment required during emergency
  - 9.9.2 Emergency procedure involving x-ray equipment
  - 9.9.3 Emergency procedure involving gamma ray source while in use (failure of source to return to safe shielded conditions, source detached from the device)
  - 9.9.4. Emergency procedure involving gamma ray source while not in use (Vehicle accidents with radioactive sealed sources; fire involving sealed sources, lost during transport, missing or stolen source)
  - 9.9.5 Emergency call list
- 9.10 Regulations
  - 9.10.1 Regulatory authorities
  - 9.10.2 Radioactive materials license requirements for industrial radiography
  - 9.10.3 Qualification requirements for radiographic source shipment

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SPECIFIC OBJECTIVES:

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- 9.1. Given the instructor's explanations, the student will be able to:
    - a) define the safety conditions under which X-ray and gamma ray equipment should be operated and the radiation detection equipment required;
    - b) handle warning systems.
  - 9.2. Given the instructor's explanations & examples of emergency situations, the student will be able to explain the possible solutions to such emergencies.
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METHODOLOGICAL STRATEGIES

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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

- 10.2.1 Basic Principle
  - 10.2.2 Differences between fluoroscopy and x- and gamma radiography
  - 10.2.3 Application
  - 10.2.4 Advantages and limitation
  - 10.3 Introduction to Digital radiography
  - 10.3.1 Introduction to CR, DDA and fluoroscopy system
  - 10.3.2 Film digitization
  - 10.3.3 Portable computed tomography system
  - 10.3.4 Advantages and limitation of digital radiography system
- 

SPECIFIC OBJECTIVES:

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- 9.5 Given the instructor's explanations, the student will be able to differentiate between conventional x- and gamma radiography and neutron radiography, fluoroscopy and digital radiography techniques and equipment associated to them
  - 9.6 Given the instructor's explanations and examples of emergency situations, the student will be able to identify various digital detectors used for digital radiography system
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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including guided discussion and problem workshop.

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EQUIPMENT AND RESOURCES:

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



## **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

### **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

#### **SUBJECT: 1. GENERAL KNOWLEDGE**

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#### **CONTENTS:**

- 1.3 Processing and defects
  - a) Materials and defects; Structure of metals and alloys
  - b) Properties of materials (metallic and non-metallic)
  - c) Discontinuities and defects in metallic materials
- 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: corrosion; creep; fatigue; wear; overload; brittle fracture
  - 1.4.3 Concepts of rupture development in metals
  - 1.4.4 Manufacturing processes and associated discontinuities
    - a. Casting processes and associated discontinuities: Ingots, blooms, and billets; Sand casting; Centrifugal casting; Investment casting
    - b. Wrought processes and associated discontinuities: forgings; rolled products; extruded products
    - c. Welding processes and associated discontinuities: submerged arc welding (SAW); shielded metal arc welding (SMAW); gas metal arc welding (GMAW); flux cored arc welding (FCAW); gas tungsten arc welding (GTAW); resistance welding; special welding processes — electron beam, electrogas etc.

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#### **SPECIFIC OBJECTIVES:**

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

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#### **METHODOLOGICAL STRATEGIES:**

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

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#### **EQUIPMENT AND RESOURCES:**

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Transparencies; films; slides; blackboard; course notes  
Samples of materials and defects

**INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**  
**SUBJECT: 1. GENERAL KNOWLEDGE**

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CONTENTS:

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- 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:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

## **SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST**

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### **CONTENTS:**

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- 2.1 Nature of penetrating radiation
  - 2.1.1 Atom and molecule
  - 2.1.2 Atomic Structure
  - 2.1.3 Atomic mass and atomic number
  - 2.1.4 Isotope and radioisotopes
  - 2.1.5 Artificial and natural radioisotopes
  - 2.1.6 Particulate and electromagnetic radiation
- 2.2 Principles of radioactive decay
  - 2.2.1 Definition of radioactivity
  - 2.2.2 Unit of radioactivity (Becquerel and Curie)
  - 2.2.3 Specific activity
  - 2.2.4 Types of radiation (alpha, beta, gamma and neutron)
  - 2.2.5 Radiation intensity and k-factor
  - 2.2.6 Radioactive Decay and decay equation
  - 2.2.7 Half life
  - 2.2.8 Modes of decay (alpha emission, beta emission and gamma emission)
- 2.3 X rays and gamma rays
  - 2.3.1 Electromagnetic spectrum
  - 2.3.2 Wavelength and energy
  - 2.3.3 X ray and gamma ray spectra
  - 2.3.4 KVp, KVc, KeV, MeV
  - 2.3.5 Inverse square Law for distance/intensity
  - 2.3.6 General properties of propagation of x and gamma ray
- 2.4 Interaction of radiation with matter
  - 2.4.1 Absorption, dispersion, photoelectric effect, Compton effect, pair production
  - 2.4.2 Absorption coefficient
  - 2.4.3 Build-up factor
  - 2.4.4 Half-value thickness and tenth value thickness
  - 2.4.4 Use of tables for calculating attenuation of gamma and X-radiations
- 2.5 Detection of ionizing radiation
  - 2.5.1 Ionization Chamber (principle of operation, range of detection, advantages and limitation)
  - 2.5.2 Geiger Muller Counter (principle of operation, range of detection, advantages and limitation)
  - 2.5.3 Scintillation detector (principle of operation, range of detection, advantages and limitation)
  - 2.5.4 Proportional counter (principle of operation, range of detection, advantages and limitation)
- 2.6 Principles of X and gamma ray detection
  - 2.6.1 Film, its accuracy of measurement and limitation
  - 2.6.2 Fluorescent material, its accuracy of measurement and limitation
  - 2.6.3 Electronic detection, its accuracy of measurement and limitation

### **SPECIFIC OBJECTIVES:**

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- 2.1 Given the instructor's explanations and a type of radiation, the student will be able to:
  - a) list its properties;
  - b) determine the characteristics of the spectrum;
  - c) determine the variation in intensity of radiation with distance;
  - d) apply properly the units related to radiographic testing.
- 2.2 Given the instructor's explanations, the student will be able to:
  - a) distinguish between radioactive decay, radioactivity and half-life;
  - b) distinguish between natural and artificial radioactive sources;
  - c) know the units of specific emission.

- 2.3 Given the instructor's explanations, the student will be able to distinguish between alpha and beta particles and neutrons.
- 2.4 Given the instructor's explanations, the student will be able to:
  - a) analyze the various mechanisms of the interaction of radiation with matter;
  - b) explain the absorption and attenuation of radiation;
- 2.5 Given the instructor's explanations, the student will be able to explain the measurement of ionization and the units used.
- 2.6 Given the instructor's explanations, the student will be able to describe the detection and measurement of X and gamma rays.

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including guided discussion and problem workshop.

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

### **SUBJECT: 3. EQUIPMENT- RADIATION SOURCES**

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CONTENTS:

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- 3.1 X-ray equipment
  - 3.1.1 Mechanism of x-ray generation
  - 3.1.2 X- ray spectrum (continuous and characteristic x-rays)
  - 3.1.3 Requirements for x-ray generation (electron source, accelerator, target material)
  - 3.1.4 X-ray tube head
  - 3.1.5 X-ray tube (cathode, anode, focal spot)
  - 3.1.6 X-ray tube window
  - 3.1.7 Tube voltage and current
  - 3.1.8 Control panel
  - 3.1.9 X-ray generation efficiency
  - 3.1.10 Heat dissipation
  - 3.1.11 Pre-filtering and Inherent filtering
  - 3.1.12 Work cycle
  - 3.1.13 Determination of focus length
  - 3.1.14 Directional and panoramic x-ray machine
  - 3.1.15 Types of circuits for X ray equipment
  - 3.1.15 Classification and selection of X ray machine
  - 3.1.16 Radiation safety features
- 3.2 Modern X-ray equipment
  - 3.2.1 Van De Graf,
  - 3.2.2 Linear accelerators,
  - 3.2.3 Betatrons
  - 3.2.4 Microfocus x-ray
  - 3.2.5 Radioscopy
- 3.3 Gamma ray sources
  - 3.3.1 Radioactive sources commonly used for industrial radiography and their characteristics
  - 3.3.2 Factors determining the choice of radiography sources (half-life, energy, specific activity, availability, focal spot size)
  - 3.3.3 Classification of Gamma cameras (Class P, M and F)

- 3.3.4 Gamma camera designs (torch type, shutter type, rotating type, remote control type, and small controlled area type)
- 3.3.5 Source changer
- 3.3.6 Collimators
- 3.3.7 Handling of gamma camera
- 3.4 Crawler
  - 3.4.1 X-ray crawler
  - 3.4.2 Gamma ray crawler
- 3.5 Maintenance of x-ray equipment and gamma camera
- 3.6 Comparison between the use of x-ray equipment and gamma camera

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SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 4.1 Photographic recording (Gamma ray, X-ray)
  - 4.1.1 Structure and composition of radiography film (protective layer, emulsion layer, protective layer, single and double coating film)
  - 4.1.2 Principle of image formation
  - 4.1.3 Characteristic curve, influence of radiation energy
  - 4.1.4 Film Characteristics (Film quality, Film graininess, Film density, Film contrast, Film definition and sharpness-effect of graininess and secondary electron)
  - 4.1.5 Film classification according to speed, type of screen used and classification according to various standards
  - 4.1.6 Film packaging (enveloped, ready packed enveloped, ready packed rolled,
  - 4.1.7 Film storage (processed and unprocessed)
  - 4.1.8 Lead, salt and fluorescent screens

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

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SPECIFIC OBJECTIVES:

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- 4.1 Given the instructor's explanations, the student will be able to:
  - a) recognize the constituent parts of a radiographic film;
  - b) relate the film code to its properties (grain size, contrast, speed);
  - c) distinguish between the types of screens and their applications;
  - d) describe sensitometric and exposure curves for various materials.
- 4.2 Given the instructor's explanations, the student will be able to:
  - a) explain fluoroscopy, image intensification, TV systems etc, based on digital radiography;
  - b) explain the differences between fluoroscopy, conventional radiography and digital radiography.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

## **SUBJECT: 5. WORK PARAMETERS AND CONDITIONS**

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### **CONTENTS:**

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- 5.1 Parameters and working conditions
    - 5.1.1 Geometrical principles, formation of umbra and penumbra
    - 5.1.2 Image density, factors which affect it
    - 5.1.3 Image quality, factors which affect it
    - 5.1.4 Radiography contrast (film contrast and subject contrast) and factors affecting them
    - 5.1.5 Radiography definition (geometrical unsharpness and inherent unsharpness) and factor affecting them
    - 5.1.6 Minimum source to Film distance
    - 5.1.7 Scattered radiation (definition, types, and causes)
    - 5.1.8 Methods of avoiding scattered radiation (Use of screens, masks, filters, collimators)
    - 5.1.9 Radiography sensitivity (concepts of sensitivity)
    - 5.1.10 Image quality indicators-IQI (types of IQI according to different standards),
    - 5.1.11 Choices of correct IQI designation
    - 5.1.12 Sensitivity calculation
    - 5.1.13 IQI positioning
    - 5.1.14. Radiography exposure and factors affecting it
    - 5.1.15 Choice of energy
    - 5.1.16 Exposure curves for X rays, gamma rays
    - 5.1.17 Exposure calculations (by past experience, using exposure curve, using characteristic curve, using special guided slide)
    - 5.1.18 Preparation of exposure curves for x- and gamma rays
    - 5.1.19 Application of exposure curve for exposure calculation (direct reading, for different source to film distances, for different materials, for different types of film)
    - 5.1.20 Choice of films
    - 5.1.21 Choice of screens
    - 5.1.22 Magnification and distortion of the projected image
    - 5.1.23 Fluoroscopy, evaluation of sensitivity, selection of KVp
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### **SPECIFIC OBJECTIVES:**

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- 5.1 Given the instructor's explanations, the student will be able to:
    - a) distinguish between the concepts of density, contrast, geometrical penumbra and definition, types of evaluation;
    - b) explain the action of various geometrical factors with respect to definition of the radiographic image;
    - c) use screens, collimators and filters for controlling scattered radiation;
    - d) distinguish between image quality indicators in accordance with the standards and explain their positioning in accordance with the test conditions;
    - e) choose the correct film type and prepare their exposure curves.
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### **METHODOLOGICAL STRATEGIES:**

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 5.2 Film processing
    - 5.2.1 Function and design of darkroom
    - 5.2.2 Safety lamps
    - 5.2.3 Equipment (manual and automatic processing unit, drying cabinets)
    - 5.2.4 Chemistry of processing solution (developer solution, stop bath, fixer)
    - 5.2.6 Care to be taken in handling and conserving the film
    - 5.2.7 Checking on the use of reagents, temperatures, processing time
    - 5.2.8 Processing procedure in darkroom (film unloading, development, rinsing, fixation, washing and drying)
    - 5.2.9 Misleading image and unsatisfactory radiographs
    - 5.2.10 Special situations
  - 5.3 Viewing of the radiographs
    - 5.3.1 General information, lighting, viewer
    - 5.3.2 Influence of the observation conditions on the detection of defects
    - 5.3.3 Checking the lighting in the viewer
    - 5.3.4 Brightness requirements
  - 5.4 Evaluation of radiographic quality
    - 5.4.1 Causes and correction of defective radiographs
    - 5.4.2 Processing defects, high density, low density, contrast, definition, fog
    - 5.4.3 Image quality indicators, IQI (types, designation, visible wire/hole, and placement)
    - 5.4.4 Identification marker
    - 5.4.4 Identification
    - 5.4.5 Density measurement
    - 5.4.6 Systematic control of radiographic quality
- 

SPECIFIC OBJECTIVES:

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- 5.2 Given the instructor's explanations and an undeveloped radiographic film, the student will be able to:
    - a) verify the conditions of the reagents and the darkroom;
    - b) handle the film correctly;
    - c) carry out the process correctly.
  - 5.3 Given the instructor's explanations and various radiographs, the student will be able to evaluate them, using the viewer and film correctly.
  - 5.4 Given the instructor's explanations and various radiographs, the student will be able to:
    - a) distinguish between defective radiographs, recognizing the various processing defects;
    - b) identify the image quality indicator;
    - c) determine the density of the radiographs.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 6.1 Basic factors
    - 6.1.1 Relation between image and object
  - 6.2 Interpretation of radiographic images
    - 6.2.1 Requirement for radiography interpreter
    - 6.2.2 Reference radiographs (welding, casting, corrosion, etc.).
    - 6.2.3 Discontinuities in welds and their radiographic appearance
    - 6.2.4 Discontinuities in casting and their radiographic appearance
    - 6.2.5 Acceptance and rejection criteria
    - 6.2.5 Factors affecting defect detectability (beam direction; geometric distortion; increase in wall thickness; Imaged thickness range; Thickness ranges for X- and g-rays, Number of exposures
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SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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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.

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EQUIPMENT AND RESOURCES:

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

# **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

## **SUBJECT: 7. SELECTION OF TECHNIQUES**

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### **CONTENTS:**

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- 7.1 Influence of the properties of the material
    - 7.1.1 Single materials
    - 7.1.2 Compound materials
  - 7.2 Basic consideration for technique selection
    - 7.2.1 Fundamental consideration
    - 7.2.2 Geometry of the specimen
  - 7.3 Selection of film, screens and radiation energy
  - 7.4 Exposure techniques depending on the geometry and accessibility of the object
    - 7.4.1 Directional Technique
    - 7.4.2 Panoramic Technique
    - 7.4.3 Single wall/single image
    - 7.4.4 Double wall/single image
    - 7.4.5 Double wall/double image
    - 7.4.6 Panoramic exposure
  - 7.5 Radiography of welds
    - 7.5.1 Seam welds
    - 7.5.2 Circumferential welds in pipes
    - 7.5.3 Nozzle welds
    - 7.5.4 Tee welds
    - 7.5.6 Diagnostic length of a weld
  - 7.6 Casting examination-Thickness compensation method
    - 7.6.1 Single thickness
    - 7.6.2 Compensation thickness method
    - 7.6.3 Diagonal method
    - 7.6.4 Multifilm method
  - 7.7 Determination of defect depth
    - 7.7.1 Right angle method
    - 7.7.2 Shift method
    - 7.7.3 Lead marker method
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### **SPECIFIC OBJECTIVES:**

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- 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.
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### **METHODOLOGICAL STRATEGIES:**

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

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### **EQUIPMENT AND RESOURCES:**

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

# **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

## **SUBJECT: 8. CODES, STANDARDS, PROCEDURE AND SPECIFICATION**

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### CONTENTS:

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- 8.1 General knowledge of codes and standards
    - 8.1.1 Differences between codes, standards, specifications and procedure
    - 8.1.2 Organizations developing codes, standards, specifications and procedure
    - 8.1.3 Classification of codes, standards, specifications and procedure (for products, testing methods, qualification and certification of personnel, radiation protection, reference radiographs)
  - 8.2 Codes and standards related to NDT
    - 8.2.1 Standards for terminology
    - 8.2.2 Standards for equipment
    - 8.2.3 Standards for testing method
    - 8.2.4 Standards for Education, Training and Certification of NDT Personnel
  - 8.3 Codes and standards related to industrial radiography
    - 8.3.1 ISO Standards
    - 8.3.2 International Institute of Welding (IIW)
    - 8.3.3 International Atomic Energy Agency (IAEA)
    - 8.3.4 American Society for Mechanical Engineer (ASME)
    - 8.3.5 British Standard
    - 8.3.6 Japanese Industrial Standard
    - 8.3.7 Standards related to the application of digital radiography
  - 8.4 Procedure and instruction
    - 8.4.1 Interpretation of procedure and compilation of test instruction
    - 8.4.2 Content and Interpretation of procedures and instruction
    - 8.4.3 Evaluation of test performance carried out by a radiographer
    - 8.4.4 Preparation of written instruction for radiography testing of given specimens (plates and pipes)
  - 8.5 Performance of test in accordance with written instructions
    - 8.5.1 Recording of operating conditions on test forms
    - 8.5.2 Execution of radiography inspection in accordance with the written instruction
    - 8.5.3 Evaluation of tasks carried out by level 1 operator
  - 8.6 Instructions for testing in special situations
    - 8.6.1 Range of application of the test, equipment and technique
    - 8.6.2 Standards, codes, and procedures for radiography
      - a) ASTM E-94, E-142 and other applicable standards
      - b) Radiographic techniques and setups
      - c) Applicable employer procedures
      - d) Procedure for radiograph parameter verification
      - e) Radiographic reports
- 

### SPECIFIC OBJECTIVES:

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- 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.
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## METHODOLOGICAL STRATEGIES:

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

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## EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

### **SUBJECT: 9. PERSONAL SAFETY AND RADIATION PROTECTION**

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## CONTENTS:

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- 9.1 Radiation quantity and units
  - 9.1.1 Exposure
  - 9.1.2 Absorbed dose
  - 9.1.3 Equivalent dose
  - 9.1.4 Effective equivalent dose
    - 9.1.4.1 Dose limit for workers, members of public and trainees
- 9.2 Biological effects of exposure to X-rays and gamma rays
  - 9.2.1 Source of radiation exposure to human being (natural, manmade and accidental)
  - 9.2.2 Acute and chronic exposure
  - 9.2.3 Somatic and genetic effects
  - 9.2.4 Stochastic and no stochastic effect
- 9.3 Personnel monitoring
  - 9.3.1 Film badges dosimeter
  - 9.3.2 Pocket dosimeters and recording its daily readings
  - 9.3.3 Thermoluminescent dosimeter
  - 9.3.4 Storage of personnel monitoring record
- 9.4 Method of controlling external exposure
  - 9.4.1 Time
  - 9.4.2 Distance
  - 9.4.2 Shielding
- 9.5 Work place monitoring
  - 9.5.1 Purpose of monitoring
  - 9.5.2 Radiation surveymeter, reading and interpreting meter indications
  - 9.5.3 Application of radiation surveymeter (e.g confirming source inside the projector, etc.)
  - 9.5.4 Recording radiation survey results
  - 9.5.5 Calibration frequency, calibration expiration action, battery check importance
- 9.6 Safety requirement for the operation in exposure room
  - 9.6.1 Introduction to a radiography exposure room
  - 9.6.2 Requirements for an X ray and gamma ray exposure rooms
  - 9.6.3 Shielding calculation of exposure room
  - 9.6.4 Layout of x- and gamma ray exposure room
  - 9.6.5 Preparation prior to commencement of works (safety equipment and accessories)
  - 9.6.6 Area monitoring before, during and after radiography works
- 9.7 Safety requirement for the operation at the open and semi open sites
  - 9.7.1 Preparation prior to commencement of works (safety equipment and accessories)
  - 9.7.2 Establishment of restricted area; posting and surveillance of restricted areas,
  - 9.7.3 Use of time, distance, and shielding to reduce personnel radiation exposure,

- 9.7.4 Use of collimators to reduce personnel exposure
- 9.7.5 Use of "source changers" for gamma ray sources
- 9.8 Emergency procedures
  - 9.8.1 Equipment required during emergency
  - 9.8.2 Emergency procedure involving x-ray equipment
  - 9.8.3 Emergency procedure involving gamma ray source while in use (failure of source to return to safe shielded conditions, source detached from the device)
  - 9.8.4. Emergency procedure involving gamma ray source while not in use (Vehicle accidents, fire involving sealed sources, lost during transport, missing or stolen source)
  - 9.8.5 Emergency call list
- 9.9 Security of radiography source
  - 9.9.1 The need for security of radiography source
  - 9.9.2. Categorization of radiography source
  - 9.9.3 Security Level
  - 9.9.4 Security function for Group B
- 9.10 Storage of gamma ray sources
  - 9.10.1 Long term storage
  - 9.10.2 Temporary storage
- 9.11 Storage of x-ray machine
- 9.12 Transport of radioactive materials
  - 9.12.1 Transport within company premises
  - 9.12.2 Transport outside company premises
  - 9.12.3 Packaging
  - 9.12.4 Labelling
  - 9.12.5 Receipt of gamma sources.
- 9.13 Disposal of gamma sources.
- 9.14 Radiography accidents and reporting
  - 9.14.1 Causes of accident
  - 9.14.2 Some examples of radiography accidents
  - 9.14.3 Lessons learned from these accidents

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SPECIFIC OBJECTIVES:

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- 9.1 Given the instructor's explanations, the student will be able to recognize the dangers of excessive exposure to X-rays or gamma rays.
- 9.2 Given the instructor's explanations and standards of radiation protection, the student will be able to recognize the maximum permissible doses of radiation and their effects on the organism.
- 9.3 Given the instructor's explanations, the student will be able to explain the variation of exposure dose with variation in time, distance or shielding.
- 9.4 Given the instructor's explanations, the student will be able to:
  - a) recognize the safety conditions under which X-ray and gamma ray equipment as well as equipment for the detection of radiation should be operated;
  - b) handle warning systems;
  - c) calculate shielding and distances.
- 9.5 Given the instructor's explanations and examples of emergency procedures and situations, the student will be able to describe the possible solutions in such emergencies.
- 9.6 Given the instructor's explanations, the student will be able to the concept of radiography source security
- 9.7. Given the instructor's explanations the student will be able to explain the subject of source categorization and its relation with the security level
- 9.8 Given the instructor's explanations and examples the student will be able to explain some accidents that occur around the world and the lesson learned out of these events

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including lecture and guided discussion.  
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EQUIPMENT AND RESOURCES:

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

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

- 10.1 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)  
10.2 Neutron Radiography  
10.3 Computed tomography (3 Dimensional Imaging)  
10.4 Stereography Radiography  
10.5 Autoradiography  
10.6 Electron emission radiography  
10.7 In motion radiography  
10.8 Flash radiography  
10.9 Television radiography  
10.10 Xero radiography  
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SPECIFIC OBJECTIVES:

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

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Instructor's presentation including lecture, demonstrations and guided discussion.  
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EQUIPMENT AND RESOURCES:

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Course notes,  
Writing board, Power Point/Transparencies, Slides/Videos,  
Examples and DIR & CT systems.  
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# **INSPECTION METHOD: RADIOGRAPHIC TESTING LEVEL: 2**

## **SUBJECT: 11. RECORDING AND INTERPRETATION OF RESULTS**

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### **CONTENTS:**

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- 11.1 Radiographic viewing
    - 11.1.1 Film-illuminator requirements, background lighting, multiple-composite viewing, dark adaptation and visual acuity
    - 11.1.2 Film identification, location markers, IQI placement, IQI designation and visible hole/wire
    - 11.1.3 Film-density measurement (application of film strip and densitometer)
    - 11.1.4 Film artifacts
  - 11.2 Radiographic evaluation
    - 11.2.1 Evaluator/interpreter checklist
    - 11.2.2 Evaluation of welds: welding method review; welding discontinuities; origin and typical orientation of discontinuities; radiographic appearance; welding codes/standards; applicable acceptance criteria; reference radiographs or pictograms
    - 11.2.3 Evaluation of castings: casting method review; casting discontinuities; origin and typical orientation of discontinuities; radiographic appearance; casting codes/standards; applicable acceptance criteria; reference radiographs
  - 11.3 Reporting test results
    - 11.3.1 Recording test results
    - 11.3.2 Content of test report
    - 11.3.3 Preparation of interim report
    - 11.3.4 Preparation of full report and other documentation
- 

### **SPECIFIC OBJECTIVES:**

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- 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.
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### **METHODOLOGICAL STRATEGIES:**

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

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### **EQUIPMENT AND RESOURCES:**

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

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

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CONTENTS: SEE BASICS LEVEL 3 SYLLABUS

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

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CONTENTS:

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- 2.1 Nature of ionizing radiation
    - 2.1.1 Corpuscular and electromagnetic radiation
    - 2.1.2 X-rays and gamma rays and their spectra
    - 2.1.3 Wavelength and energy
  - 2.2 Radioactive decay
    - 2.2.1 Radioactivity, half -life
    - 2.2.3 Decay series
    - 2.2.4 Artificial and natural sources
    - 2.2.5 Alpha and beta particles, neutrons
    - 2.2.6 Measurement of intensity, k-factor
  - 2.3 Interaction of radiation with matter
    - 2.3.1 Absorption, scattering, photoelectric effect, Compton effect, pair production
    - 2.3.2 Absorption coefficient; Half and tenth value layers
    - 2.3.3 Calculation of attenuation coefficient for simple materials and compounds
    - 2.3.4 Radiographic equivalents
    - 2.3.5 Build-up factors
    - 2.3.6 sky-shine effect
  - 2.4 Measurement of ionization and units
    - 2.4.1 Detection of radiation by ionization, scintillation etc.
  - 2.5 Principles of detection by means of film, fluorescent material or electric and electronic systems in radiographic testing
- 

SPECIFIC OBJECTIVES:

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- 2.1 Given the instructor's explanations, the student will be able to describe the spectral characteristics and nature of ionizing radiation.
  - 2.2 Given the instructor's explanations, the student will be able to explain the concepts and parameters relating to the radioactive sources used in the testing.
  - 2.3 Given the instructor's explanations, the student will be able to:
    - a) describe various mechanisms for the interaction of radiation with matter and its application in radiographic testing;
    - b) explain the absorption and attenuation of radiation in materials.
  - 2.4 Given the instructor's explanations, the student will be able to solve problems relating to radiation detection and dosimetry.
  - 2.5 Given the instructor's explanations, the student will be able to explain the principles applied in various detection systems.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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



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

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CONTENTS:

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- 3.1 Industrial radiation sources
    - 3.1.1 X ray generators,
    - 3.1.2 Beam opening characteristics
    - 3.1.3 X-ray flash devices
    - 3.1.4 Rod anode devices
    - 3.1.5 Micro-focus devices;
    - 3.1.6 High-voltage devices.
    - 3.1.7 Line focus tubes
    - 3.1.8 Rotary anode tubes
    - 3.1.9 Van Der Graft, linear accelerators, betatrons
    - 3.1.10 Inherent filtering
    - 3.1.11 Hardening effect
    - 3.1.12 Method for measurement of focal spot according to standard
    - 3.1.13 Equipment for gamma radiation and neutron generators
    - 3.1.14 Purchase, acceptance, operation and maintenance
    - 3.1.15 Shielding, filtering and collimation
  - 3.2 Facilities for industrial radiography (design and construction of an exposure room)
  - 3.3 Accessories
- 

SPECIFIC OBJECTIVES:

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

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 4.1 Photographic recording
  - 4.1.1 Films used in radiography, principles, properties, types of emulsions (granularity), influence of radiation, energy, characteristic curves
  - 4.1.2 Radiographic quality, density, contrast, definition, sharpness
  - 4.1.3 Types of films for industrial radiography

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

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SPECIFIC OBJECTIVES:

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- 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, real time radiography, and digital radiography and get acquainted with CT systems.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 5.1 Operating parameters and image quality in radiographic testing
  - 5.1.1 Radiographic sensitivity
- 5.2 Operating techniques for real-time fluoroscopy and direct digital image recording
  - 5.2.1 Testing sensitivity, fluctuation and resolution
  - 5.2.2 Evaluation of digital image data
- 5.3 Film processing, equipment, facilities and reagents
  - 5.3.1 Handling and conservation
  - 5.3.2 Special situations
  - 5.3.3 Influence of the observations conditions in defect detection

- 5.3.4 Lighting control in viewers
- 5.3.5 Brightness requirements
- 5.3.6 Causes of defective radiographs and correction there of
- 5.3.7 Processing defects
- 5.3.8 Systematic control of radiographic quality
- 5.4 Conditions for observing radiographs
- 5.4.1 Lighting and perceptibility

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SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 6.1 Interpretation of radiographic images
- 6.1.1 Relation between image and object
- 6.2 Requirement for radiography interpreter
- 6.2.1 Standard reference radiographs (IIW, ASTM, etc for welding, casting, corrosion, etc.).
- 6.2.2 Discontinuities in welds, their source, effect to weld integrity and their radiographic appearance
- 6.2.3 Discontinuities in casting, their source, effect to product integrity and their radiographic appearance
- 6.2.4 Influence on detectability (beam direction; geometric distortion; increase in wall thickness; Imaged thickness range; Thickness ranges for X- and gamma-rays; Number of exposures vs. Distortion angle)

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SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 7.1 Influence of the properties of materials
    - 7.1.1 Compound materials
  - 7.2 Exposure technique depending on the geometry and accessibility of the object
    - 7.2.1 Single wall/single image
    - 7.2.2 Double wall/single image
    - 7.2.3 Double wall /double image
    - 7.2.4 Panoramic exposure
    - 7.2.5 Compensation for thickness
    - 7.2.6 Masks
  - 7.3 Probability of detection (POD) according to type, size, position and orientation of the defect
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SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 8.1 National and international codes and standards for radiographic testing
  - 8.1.1 Bodies producing standards (ISO, ASTM, ASME, BS, EN, etc.)
  - 8.1.2 Interpretation of some standards related to radiography testing (e.g ASME Section V, Article 2)
- 8.2 Specifications for radiographic testing
  - 8.3 Radiography procedure
    - 8.3.1 Requirement for written procedure in code and standard
    - 8.3.2 Content of radiography procedure

8.3.3 Radiographic procedure writing as per given reference codes.

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SPECIFIC OBJECTIVES:

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

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 9.1 Radiation and its effects
  - 9.1.1 Biological effects of radiation
  - 9.1.2 Mechanism of radiation damage to human cell
  - 9.1.3 Effect of radiation (somatic, genetic and risk of the pregnant women)
  - 9.1.4 Comparison of risk due to other activities (e.g smoking)
  - 9.1.5 International regulations and recommendations for radiation protection
- 9.2 Equipment and facilities
  - 9.2.1 Design and calculation of shielding for equipment and facilities
  - 9.2.2 Design of packaging for the transport of radioactive sources
  - 9.2.3 Verification of radiation of leaks from X-ray and gamma ray equipment
- 9.3 Operational procedures
  - 9.3.1 Safety in equipment and facilities for industrial radiography
  - 9.3.2 Maintenance of equipment for scintiscanning
- 9.4 Radiation safety conditions for work in the field
  - 9.4.1 Operational procedure
  - 9.4.2 Precaution for site gamma radiography
- 9.5 Radiological safety responsibility
  - 9.5.1 Operating organizations
  - 9.5.2 Radiation protection Officers
  - 9.5.3 Radiographers
  - 9.5.4 Radiography client
- 9.6 Radiation Protection Program
  - 9.6.1 Objective and scope
  - 9.6.2 Radiation Protection Program Content
  - 9.6.3 Control of industrial radiography source
- 9.7 Security of radioactive source used in industrial radiography
  - 9.7.1 Categorization of radiography sources
  - 9.7.2 Security level
  - 9.7.3 Security function, security objective

- 9.7.4 Radiation security program
- 9.7.5 Storage of radiography source

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SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 10.1 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)
  - 10.2 Neutron Radiography
  - 10.3 Computed tomography (3 Dimensional Imaging)
  - 10.4 Stereography Radiography
  - 10.5 Autoradiography
  - 10.6 Electron emission radiography
  - 10.7 In motion radiography
  - 10.8 Flash radiography
  - 10.9 Television radiography
  - 10.10 Xero radiography
  - 10.11 Radiography of concrete construction
    - 10.11.1 Standard related to radiography inspection of concrete
    - 10.11.2 Radiographic image of concrete internal structure
  - 10.12 Radiography of non-metallic materials (plastics, ceramics, compounds, etc.)
  - 10.13 Application of radiographic techniques in non-conventional areas
    - 10.13.1 Aeronautics and aerospace
    - 10.13.2 Offshore structures
    - 10.13.3 Others
- 

SPECIFIC OBJECTIVES:

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

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 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
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SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

# **ULTRASONIC TESTING**



# **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 1**

## **SUBJECT: 1. GENERAL KNOWLEDGE**

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### CONTENTS:

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- 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 particle testing
      - d) Radiographic testing
      - e) Ultrasonic testing
      - f) Eddy current testing
      - g) Leak testing
    - 1.1.4 Limitations in the application of ultrasonic testing
    - 1.1.5 Responsibilities of the levels of certification
  - 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:

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- 1.1 Given the instructor's explanations, the student will be able to:
    - b) define the nature of a non-destructive test;
    - c) list the characteristics of NDT technology and the reasons for using NDT;
    - d) 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.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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

SPECIFIC OBJECTIVES:

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

METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Transparencies  
Slides  
Films  
Course notes  
Samples of materials with typical defects

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

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### **CONTENTS:**

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- 2.1 General concepts
    - 2.1.1 Definition of ultrasonic
    - 2.1.2 History of ultrasonic testing
    - 2.1.3 Applications of ultrasonic energy
    - 2.1.4 Properties of sound and propagation of mechanical waves
  - 2.2 Concepts relating to frequency, amplitude, wave length and speed of propagation
  - 2.3 Acoustic impedance
  - 2.4 Influence of wave type on the test method
    - 2.4.1 Longitudinal waves and transverse waves
    - 2.4.2 Surface waves and Lamb waves
  - 2.5 Reflection and refraction
    - 2.5.1 Modes conversion
    - 2.5.2 Attenuation
    - 2.5.3 Snell's law and critical angles
  - 2.6 Ultrasonic wave transfer from one medium to another
    - 2.6.1 Generation of ultrasonic waves
    - 2.6.2 Ultrasonic losses in different media
  - 2.7 Piezoelectric effect, characteristics and types of crystals, piezoelectric constants
  - 2.8 Sonic field influence of speed of sound and transducer size
  - 2.9 Types of transducers; normal; emitter-receiver; angular
  - 2.10 Influence of transducer's frequency and diameter (add)
  - 2.11 The sonic path; near field; far field; beam divergence
  - 2.12 Couplant
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### **SPECIFIC OBJECTIVES:**

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- 2.1 Given the instructor's explanations, the student will be able to list the properties of ultrasonic waves.
- 2.2 Given the instructor's explanations, the student will be able to:
  - a) define frequency, amplitude, length, speed of propagation;
  - b) state the mathematical expression relating speed of propagation, wavelength and frequency.
- 2.3 Given the instructor's explanations, the student will be able to define acoustic impedance, stating the corresponding mathematical expressions.
- 2.4 Given the instructor's explanations, the student will be able to:
  - a) define longitudinal and transverse waves, specifying their characteristics;
  - b) state the relationship between wave type and application of test.
- 2.5 Given the instructor's explanations, the student will be able to:
  - a) define reflection and refraction;
  - b) represent graphically the possible mode conversions when the beam is incident at non-zero angle with respect to normal;
  - c) state the causes of attenuation.
- 2.6 Given the instructor's explanations, the student will be able to:
  - a) state the principle of conservation of energy;
  - b) list the energies involved in ultrasonic testing, describing the way in which the energies change.
- 2.7 Given the concept of piezoelectricity, the student will be able to:
  - a) define its nature;
  - b) list the materials which exhibit this property and which are currently used in ultrasonic.
- 2.8 Given the instructor's explanations, the student will be able to:
  - a) define sonic field;

- b) explain the relationship between transducer size, frequency and tested material on sonic field.
- 2.9 Given the instructor's explanations and a transducer, the student will be able to:
- a) recognize its type and structural characteristics;
  - b) compare it with the other types of transducers, stating the basic differences between them;
  - c) describe its use or application.
- 2.10 Given the instructor's explanations and the concepts of near field and far field the student will be able to:
- a) state the characteristics of each and the main differences between them;
  - b) state the mathematical relationship which limits them;
  - c) represent graphically the sonic field for a transducer, indicating the near and the far field;
  - d) correctly interpret the beam shape for different transducers.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 1**

### **SUBJECT: 3. TESTING TECHNIQUES AND THEIR LIMITATIONS**

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CONTENTS:

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- 3.1 Pulse- echo technique:
    - 3.1.1 By direct contact
    - 3.1.2 Immersion
      - a) Transducers in water
      - b) Water column, wheels
      - c) Submerged test part
      - d) Sound-beam path — transducer to water path length
      - e) Focused transducers
      - f) Curved surfaces
      - g) Comparison of contact and immersion methods
    - 3.1.3 Pitch catch transducers
  - 3.2 Transmission technique
  - 3.3 Resonance technique
  - 3.4 Methods of coupling
  - 3.5 Testing with automatic systems and on the production line

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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;
- f) setting range and sensitivity.

3.5 Given the instructor's explanations, the student will be able to list the characteristics of an automatic testing system;

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including lecture and guided discussion.

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

- 4.1 Description of the basic testing equipment with display of the information in a representation (A-scan)
- 4.2 Basic B-C scan and computerized systems.
- 4.3 Analog and digital equipment for thickness measurements
- 4.4 Controls and Functions
  - 4.4.1 Functions
  - 4.4.2 Use
  - 4.4.3 Recorders
  - 4.4.4 Alarms
  - 4.4.5 Automatic and semi-automatic systems
  - 4.4.6 Electronic distance/amplitude correction
  - 4.4.7 Transducers — structure, types of crystals, frequency (crystal-thickness relationships)
  - 4.4.8 Beam spread
  - 4.4.9 Sensitivity, resolution and damping
  - 4.4.10 Couplants

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SPECIFIC OBJECTIVES:

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

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 5.1 Distance calibration for normal single and double crystal transducers (transmitter/receiver)
  - 5.2 Angular transducers of transverse waves
    - 5.2.1 Sonic path calibration (distance, angle)
    - 5.2.2 Projected distance, pulse echo variables, transmission factors
    - 5.2.3 Shortened projected distance
  - 5.3 Checking the calibration: consideration of differences in speed of propagation between calibration block and test piece, comparison with reference blocks
  - 5.4 Variable effects, transmission accuracy
  - 5.5 Calibration requirements and reflectors
  - 5.6 Inspection calibration
- 

SPECIFIC OBJECTIVES:

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

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

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 1**

### **SUBJECT: 6. SPECIFIC APPLICATIONS**

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#### CONTENTS:

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- 6.1 Testing of specimens of simple geometries
    - 6.1.1 Examination of sheets
    - 6.1.2 Examination of billets
    - 6.1.3 Examination of castings.
  - 6.2 Thickness measurements
    - 6.2.1 Influence of material type
    - 6.2.2 Influence of surface condition
  - 6.3 Influence of geometry and structure
  - 6.4 Detection of corrosion
- 

#### SPECIFIC OBJECTIVES:

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- 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.
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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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

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## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 1**

### **SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES**

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#### CONTENTS:

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- 7.1 General knowledge
  - 7.2 Codes and standards
  - 7.3 Performance of tests in accordance with written instructions, selection of parameters
  - 7.4 Recording of results
  - 7.5 Preparation of test reports
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#### SPECIFIC OBJECTIVES:

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

7.4 Given the instructor's explanations and requisite forms, the student will be able to prepare the test report completing all of its requirements.

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METHODOLOGICAL STRATEGIES

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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

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SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES

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Instructor's presentation including guided discussion and practical work.

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EQUIPMENT AND RESOURCES:

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



**INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2**  
**SUBJECT: 1. GENERAL KNOWLEDGE**

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CONTENTS:

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- 1.1 Basic principles of NDT
    - 1.1.1 Definitions and methodology of applications of basic methods, VT, PT, MT, RT, UT, ET, LT
    - 1.1.2 Fields of application of common methods
    - 1.1.3 Range and limitations of common methods, including the subject method
    - 1.1.4 New developments in NDT
    - 1.1.5 Responsibilities of levels of certification
  - 1.2 Materials
    - 1.2.1 Physical and mechanical properties of materials (metallic and non-metallic)
    - 1.2.2 Structures of metals and alloys
    - 1.2.3 Indications, discontinuities and defects
    - 1.2.4 In-service and manufacturing discontinuities
- 

SPECIFIC OBJECTIVES:

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- 1.1 Given the instructor's explanations, the student will be able to:
    - a) define non-destructive testing;
    - b) describe the basic principles and the method of application of the common NDT methods;
    - c) discuss the best applications, limitations and problems relating to the use of each method.
  - 1.2 Given the instructor's explanations, the student will be able to:
    - a) describe the structure, physical and mechanical properties of metallic materials
    - b) describe the various types of discontinuities and defects, their sources and their classification.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Transparencies  
Slides  
Films  
Writing board  
Course notes

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**INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2**  
**SUBJECT: 1. GENERAL KNOWLEDGE**

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CONTENTS:

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- 1.3 Processing and defects
  - 1.3.1 Primary processes and related defects
  - 1.3.2 Manufacturing processes and related defects:
    - a) Casting processes and associated discontinuities: ingots, blooms, and billets; sand casting; centrifugal casting; investment casting
    - b) Wrought processes and associated discontinuities: forgings; rolled products; extruded products

c) Welding processes and associated discontinuities: submerged arc welding (SAW); shielded metal arc welding (SMAW); gas metal arc welding (GMAW); flux cored arc welding (FCAW); gas tungsten arc welding (GTAW); resistance welding; special welding processes — electron beam, electrogas, etc.

1.4 Materials in service

1.4.1 Behaviour of materials in service

1.4.2 Service conditions leading to defects and failures: corrosion; creep; fatigue; wear; overload; brittle fracture, erosion, others

1.4.3 Concepts of rupture development in metals

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SPECIFIC OBJECTIVES:

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

- a) describe the common primary metallurgical processes and the related defects;
- b) describe the common manufacturing processes and the related defects.

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

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

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Transparencies

Films

Slides

Writing board

Course notes

Samples of materials and defects

## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2**

### **SUBJECT: 1. GENERAL KNOWLEDGE**

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CONTENTS:

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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

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SPECIFIC OBJECTIVES:

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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.

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including lecture, guided discussion and review of examples.  
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EQUIPMENT AND RESOURCES:  
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Transparencies  
Films  
Slides  
Writing board  
Course notes  
Typical documents, i.e. codes

**SUBJECT: 2. TERMINOLOGY, PHYSICAL PRINCIPLES AND FUNDAMENTALS OF ULTRASONICS**  
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CONTENTS:  
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- 2.1 The nature of ultrasonic waves
- 2.2 Characteristics of wave propagation
  - 2.2.1 Frequency
  - 2.2.2 Amplitude
  - 2.2.3 Wave length
  - 2.2.4 Velocity
  - 2.2.5 Acoustic impedance
  - 2.2.6 Acoustic pressure
  - 2.2.7 Acoustic energy
  - 2.2.8 Acoustic intensity
- 2.3 Types of ultrasonic waves and their applications
  - 2.3.1 Longitudinal wave
  - 2.3.2 Transverse wave
  - 2.3.3 Surface wave
  - 2.3.4 Extensive knowledge of Rayleigh and Lamb waves
- 2.4 Behavior of ultrasonic waves: normal incidence; angular incidence; reflection and refraction; mode conversion
- 2.5 Transfer of energy from one medium to another
  - 2.5.1 Generation of ultrasonic waves
  - 2.5.2 Energy losses in various media
- 2.6 Piezoelectric and magneto restrictive effect on the crystal
- 2.7 Characteristics of the sound beam
  - 2.7.1 Far field and near field
  - 2.7.2 Influence of sound velocity and transducer size
  - 2.7.3 Field divergence
- 2.8 Attenuation of sound: Cause and effect; principles of measurement of attenuation

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

- 2.4 Given the instructor's explanations, the student will be able to:
  - a) distinguish between normal and angular incidence;
  - b) define reflection and refraction;
  - c) explain mode conversion.
- 2.5 Given the instructor's explanations, the student will be able to:
  - a) describe the characteristics of energy transfer from one medium to another;
  - b) explain the generation of ultrasonic waves and the cause of energy loss in various media.
- 2.6 Given the instructor's explanations, the student will be able to:
  - a) explain the piezoelectric and magnetostrictive effects;
  - b) compare the advantages and disadvantages of various crystal materials.
- 2.7 Given the instructor's explanations of the concepts of near and far field. The student will be able to:
  - a) identify the characteristics of near and far fields and differentiate between them;
  - b) state the limiting mathematical relationship;
  - c) illustrate graphically the sonic field for a transducer, indicating the near and far fields;
  - d) interpret correctly the sonogram for different sensors.
- 2.8 Given the instructor's explanations, the student will be able to define ultrasonic attenuation

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**METHODOLOGICAL STRATEGIES:**

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Instructor's presentation including lecture and guided discussion.

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**EQUIPMENT AND RESOURCES:**

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

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

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**CONTENTS:**

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- 3.1 Test methods: transmission method; pulse-echo method; resonance method; automatic and semi-automatic methods
- 3.2 Transducers: normal incidence angular incidence transducers; special transducers
- 3.3 Techniques: tandem techniques; focused transducers technique; double-crystal transducers technique; surface-wave transducers technique; immersion techniques
- 3.4 Limitations in the application of the ultrasonic test method.
- 3.5 Defect sizing techniques: maximum amplitude; 6db drop; 20db drop; distance gain size (DGS)
- 3.6 Discontinuity detection:-
  - 3.6.1 Sensitivity to reflections
  - 3.6.2 Resolution
  - 3.6.3 Determination of discontinuity size
  - 3.6.4 Location of discontinuity.
- 3.7 Setting test sensitivity
  - 3.7.1 Distance amplitude correction (DAC)
  - 3.7.2 DGS
  - 3.7.3 Attenuation and transfer correction. Beam divergence factor
- 3.8 Echo classification systems: pattern responses 1,2,3a,3b,4 (BS 3923); planar defects; volumetric defects; discrete reflectors; diffuse reflectors.

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**SPECIFIC OBJECTIVES:**

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- 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.

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**METHODOLOGICAL STRATEGIES:**

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Instructor's presentation including lecture and guided discussion.

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**EQUIPMENT AND RESOURCES:**

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

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

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**CONTENTS:**

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- 4.1 Construction and mode of operation of ultrasonic equipment
  - 4.1.1 Functions of the electronic elements in a typical instrument
  - 4.1.2 Types of instrumentation:
    - a) portable
    - b) laboratory (statutory)
    - c) digital
    - d) automated and semi-automated systems
- 4.2 Characteristics of equipment and system controls
  - 4.2.1 Properties of vertical and horizontal amplifiers
  - 4.2.2 Correlation between resolving power and frequency, transmitting power, damping
  - 4.2.3 Linearity
  - 4.2.4 Saturation and amplifier threshold
- 4.3 Signal presentation: echo amplitude and its control; more in-depth knowledge on Ascan; B-scan; C-scan; correlation of digital and analogue signals
- 4.4 Recording instrumentation
  - 4.4.1 Automatic monitors
  - 4.4.2 Computer interfacing
  - 4.4.3 Recorders, printers and color markers

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**SPECIFIC OBJECTIVES:**

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- 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.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 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 VI 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 Sizing techniques, principles and limitations
  - 5.7 Coupling medium

---

SPECIFIC OBJECTIVES:

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

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2**

### **SUBJECT: 6. SPECIFIC APPLICATIONS**

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#### CONTENTS:

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- 6.1 Methods of examination
    - 6.1.1 Cast work pieces
    - 6.1.2 Welded work pieces
    - 6.1.3 Components and systems
    - 6.1.4 Austenitic materials
    - 6.1.5 Forged work pieces
    - 6.1.6 Non-metallic materials (ceramics, plastics, etc.)
    - 6.1.7 Bonded structures
- 

#### SPECIFIC OBJECTIVES:

---

- 6.1 Given the instructor's explanation and demonstrations, the student will be able to:
    - a) explain how the test should be performed, the type of transducers to be used, the frequency, probe angle and scanning direction and sizing techniques;
    - b) describe the manufacturing processes, geometries and possible types of discontinuities in each case.
- 

#### METHODOLOGICAL STRATEGIES:

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

---

#### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2**

### **SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES**

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#### CONTENTS:

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- 7.1 Codes, standards and specifications specifically related to ultrasonic testing
- 7.2 Testing procedures:
  - 7.2.1 Selection and verifications of equipment
  - 7.2.2 Position and direction of scan
  - 7.2.3 Calibration
  - 7.2.4 Comparison procedures
    - a) Standards and references
    - b) Amplitude area and distance relationship
    - c) Application of results of other NDT methods
  - 7.2.5 Object appraisal
    - a) History of part
    - b) Geometry of part
    - c) Intended use of part

- d) Interpretation to code/specification
- e) Type and location of discontinuity.

---

SPECIFIC OBJECTIVES:

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- 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:

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Instructor's presentation including lecture and guided discussion

---

EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

---

- 8.1 Response of the equipment to various types of defects
  - 8.2 Interpretation of relevant codes and standards
  - 8.3 Evaluation of discontinuities in accordance with specifications, standards and codes
  - 8.4 Recording and reporting the results of a test, storage of records, traceability
- 

SPECIFIC OBJECTIVES:

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

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

---

EQUIPMENT AND RESOURCES:

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



# **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 2**

## **SUBJECT: 9. SPECIAL TECHNIQUES**

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### CONTENTS:

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- 9.1 Special inspection problems and techniques used to solve them
  - 9.2 Automated and semi- automated testing techniques
  - 9.3 Special techniques for data processing
  - 9.4 Time of flight diffraction, ToFD
  - 9.5 Automatic UT (P scan)
  - 9.6 Phased array
  - 9.7 C scan (portable C scan)
  - 9.8 Corrosion mapping and detection (T scan)
  - 9.9 Guided waves.
- 

### SPECIFIC OBJECTIVES:

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- 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.
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### METHODOLOGICAL STRATEGIES:

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Instructor's presentation including demonstration.

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### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3**

### **SUBJECT: 1. GENERAL KNOWLEDGE**

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CONTENTS: SEE BASIC LEVEL 3 SYLLABUS

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## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3**

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

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CONTENTS:

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- 2.1 Nature of ultrasonic waves
  - 2.2 Characteristics of ultrasonic wave propagation: frequency, wavelength, velocity, acoustic impedance, acoustic energy, acoustic intensity, amplitude.
  - 2.3 Types of ultrasonic waves and their applications:
    - 2.3.1 Longitudinal wave
    - 2.3.2 Transverse wave
    - 2.3.3 Surface wave
    - 2.3.4 Lamb wave
  - 2.4 Behavior of ultrasonic waves
    - 2.4.1 Normal incidence
    - 2.4.2 Angular incidence
    - 2.4.3 Reflection and refraction
    - 2.4.4 Methods of mode conversion
    - 2.4.5 Snell's law
    - 2.4.6 Modes of sound wave propagation.
- 

SPECIFIC OBJECTIVES:

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- 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.
  - 2.5 Transfer of energy from one medium to another, generation of ultrasonic waves, energy losses in various media.
  - 2.6 Piezoelectric effect and magnetostrictive effect in crystals
  - 2.7 Isotropic and anisotropic materials, phenomena of guided propagation
  - 2.8 Far field and near field, influence of the speed of sound and the size of the transducer, divergence of the field, Fresnel and Fraunhofer zones.
  - 2.9 Attenuation of sound, cause, effect, principles of measurement
  - 2.10 Relation between sound velocity and elastic properties in metal
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METHODOLOGICAL STRATEGIES:

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Instructor's demonstration including guided discussion

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 3.1 Testing methods:
    - 3.1.1 Transmission method
    - 3.1.2 Pulse-echo method
    - 3.1.3 Resonance method
    - 3.1.4 Automatic and semi- automatic methods
      - a) Time of flight diffraction
      - b) Phased array
      - c) C scan (Portable C scan)
      - d) Guided wave
      - e) Corrosion Mapping (T scan)
  - 3.2 Transducers:
    - 3.2.1 Normal -incidence transducers
    - 3.2.2 Angular- incidence transducers
    - 3.2.3 Special transducers
  - 3.3 Techniques:
    - 3.3.1 Tandem technique
    - 3.3.2 Focalized transducers technique
    - 3.3.3 Double crystal technique
    - 3.3.4 Surface -wave transducers technique
    - 3.3.5 EMAT transducers
    - 3.3.6 Multi probe arrays
    - 3.3.7 Immersion techniques
      - a) Transducer in water
      - b) Water column, wheels etc
      - c) Submerged test part
      - d) Sound beam path — transducer to part
      - e) Testing of curved surfaces.
  - 3.4 Limitations to the application of ultrasonic testing
  - 3.5 Preparation of Written Producers
- 

SPECIFIC OBJECTIVES:

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

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Instructor' s demonstration including guided discussion.

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: ULTRASONIC TESTING LEVEL: 3**

### **SUBJECT: 4. EQUIPMENT AND ACCESSORIES**

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#### CONTENTS:

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- 4.1 Construction and mode of operation of ultrasonic equipment
  - 4.1.1 Functions of the electronic elements in a typical instrument
  - 4.1.2 Types of equipment:
    - a) portable
    - b) laboratory (statutory)
    - c) digital
    - d) automated installations
- 4.2 Characteristics of equipment and system controls
  - 4.2.1 Properties of vertical and horizontal amplifiers
  - 4.2.2 Correlation between resolving power and frequency, transmitting power, damping
  - 4.2.3 Linearity
  - 4.2.4 Saturation and amplifier threshold
- 4.3 Signal presentation: Echo amplitude and its control; A-scan; B-scan; C-scan; P-scan; Tscan; correlation of digital and analogue signals
- 4.4 Recording instrumentation
  - 4.4.1 Automatic monitors
  - 4.4.2 Computer interfacing
  - 4.4.3 Recorders, printers and color markers

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#### SPECIFIC OBJECTIVES:

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- 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.

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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 5.1 Calibration and adjustment of the equipment:
    - 5.1.1 Calibration of equipment electronics
      - a) variable effects,
      - b) transmission accuracy
    - 5.1.2 Accessories
    - 5.1.3 Control of calibration
  - 5.2 Calibration of the sensitivity of the test, different geometric conditions.
    - 5.2.1 Reference reflectors for calibration
      - a) Balls, side drilled and flat bottomed holes
      - b) Area amplitude blocks
      - c) Distance amplitude blocks
      - d) Notches
      - e) Special blocks, I.I.W and others
    - 5.2.2 Design and preparation of calibration units
    - 5.2.3 Various calibration criteria (D.A.C., D.G.S., etc.) and selection of suitable reflectors
    - 5.2.4 Exact measurement of speed of propagation, use of interferometers.
  - 5.3 Transmission of ultrasonic energy across the surface being explored
    - 5.3.1 Condition of surface, curvature
    - 5.3.2 Precautions against excitation
    - 5.3.3 Crystal diameter and coupling medium
    - 5.3.4 Connecting cables: insulation, flexibility, contact pins.
- 

SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 6.1 Methods of examination
  - 6.1.1 Cast work pieces
  - 6.1.4 Welded work pieces

- 6.1.5 Components and systems
- 6.1.4 Austenitic materials
- 6.1.5 Forged work pieces
- 6.1.8 Non-metallic materials (ceramics, plastics, etc.)
- 6.1.9 Bonded structures

---

SPECIFIC OBJECTIVES:

---

- 6.1 Given the instructor's explanation and demonstrations, the student will be able to:
    - a) explain how the test should be performed, the type of sensor to be used, the frequency, probe angle and scanning direction
    - b) describe the manufacturing processes, geometries and possible types of discontinuities in each case.
- 

METHODOLOGICAL STRATEGIES:

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Instructor's presentation including guided discussion.

---

EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 7.1 Examination specifications
    - 7.1.1 Function of design engineering
    - 7.1.2 Design and building codes
    - 7.1.3 ASME Code
  - 7.2 Standards for ultrasonic testing
    - 7.2.1 Specific standards for testing with ultrasonic (ASTM, JIS, EN)
    - 7.2.2 Interpretation of specifications, codes and standards
  - 7.3 Test procedures
    - 7.3.1 Drafting of test procedures
    - 7.3.2 General and specific procedures — Specific applications to be considered
      - a) Detection of flaws
      - b) Thickness assessment
      - c) Bond evaluation
      - d) Fluid flow measurements
      - e) Material properties measurements
      - f) Computer control and defect analysis
      - g) Liquid level setting
      - h) Process control
      - i) Field inspection
    - 7.3.3 Safety and health consideration: electric shock; mechanical hazards; pneumatic hazards; chemical contamination
- 

SPECIFIC OBJECTIVES:

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- 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.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

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

---

CONTENTS:

- 
- 8.1 Response of the equipment to the various types of defect
  - 8.2 Evaluation of discontinuities, in accordance with specifications, standards and codes
  - 8.3 Development of acceptance criteria into written procedures
  - 8.4 Recording and reporting on the test

---

SPECIFIC OBJECTIVES:

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

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METHODOLOGICAL STRATEGIES:

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Instructor's demonstration including guided discussion.

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EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 9.1 Special techniques
    - 9.1.1 Ultrasonic holography
    - 9.1.2 Ultrasonic spectroscopy
    - 9.1.3 Time of Flight Diffraction, ToFD
    - 9.1.4 Phase Array
    - 9.1.5 Automated and semi- automated testing techniques
    - 9.1.6 Special techniques for data processing
- 

SPECIFIC OBJECTIVES:

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- 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:

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

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EQUIPMENT AND RESOURCES:

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



## **VISUAL TESTING**

# **INSPECTION METHOD: VISUAL TESTING LEVEL: 1**

## **SUBJECT: 1. GENERAL KNOWLEDGE**

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### CONTENTS:

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- 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 particle testing, d) radiographic testing, e) ultrasonic testing, f) eddy current testing, g) leak testing
    - 1.1.4 Advantages of visual testing
    - 1.1.5 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
  - 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 related defects
      - a) overload, b) fatigue, c) creep, d) corrosion, e) brittle fracture, f) others
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### SPECIFIC OBJECTIVES:

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- 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;
    - d) explain the terms NDE, NDT and NDI..
  - 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.
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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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Writing board  
Transparencies  
Slides Film (if available)  
Course notes

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

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CONTENTS:

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- 2.1 Fundamentals of visual and optical testing
    - 2.1.1 Description of visual and optical testing
    - 2.1.2 Nature of light
      - a) Wave theory
      - b) Quantum theory
    - 2.1.3 Measurement of properties of light
  - 2.2 Sources of light
    - 2.2.1 Electromagnetic radiation, light spectra
    - 2.2.2 Characteristics of light, intensity and color
    - 2.2.3 Measurement of properties of light
    - 2.2.4 Illumination and luminance
    - 2.2.5 Experimental laws of photometry
    - 2.2.6 Units
  - 2.3 Phenomena of regular and diffuse reflection, refraction, dispersion, diffraction, absorption and transmission of light
  - 2.4 Emissivity and reflectance
- 

SPECIFIC OBJECTIVES:

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- 2.1 Given the instructor's explanations, the student will be able to:
    - a) list properties of light;
    - b) List other electromagnetic radiation;
    - c) differentiate between intensity and colour.
  - 2.2 Given the instructor's explanations, the student will be able to:
    - a) describe source of light;
    - b) differentiate between illumination and luminance;
    - c) establish variation of light intensity with distance.
  - 2.3 Given the instructor's explanations, the student will be able to enumerate different phenomena occurring during transmission of light through different media.
  - 2.4 Given the instructor's explanations, the student will be able to differentiate between emissivity and reflectance.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Slides, Power Point/Transparencies, Slides/Videos, writing board, course notes, various equipment for light emission.

## **INSPECTION METHOD: VISUAL TESTING LEVEL: 1**

### **SUBJECT: 3. VISION**

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#### CONTENTS:

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- 3. Physiological factors, eyes, components, visual functions
    - 3.1 Human eye
      - 3.1.1 Physical description and formation of image
      - 3.1.2 Perception of intensity and color
      - 3.1.3 Visual acuity
    - 3.2 Reaction of the eye to light excitation
      - 3.2.1 Sensitivity and adaptation to variations
      - 3.2.2 Perception of contrast and color
    - 3.3 Vision defects
      - 3.3.1 Symptomatic disturbances of vision
        - a) Partial loss of vision
        - b) Complete loss of vision
- 

#### SPECIFIC OBJECTIVES:

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- 3.1 Given the instructor's explanations, the student will be able to:
    - a) identify the main components of the human eye;
    - b) differentiate between intensity and color perception;
    - c) define visual acuity.
  - 3.2 Given the instructor's explanations, the student will be able to:
    - a) recognize threshold limits for intensity and color perception;
    - b) enumerate vision defects.
- 

#### METHODOLOGICAL STRATEGIES:

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Instructor's presentation including lectures and guided discussions.

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#### EQUIPMENT AND RESOURCES:

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

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## **INSPECTION METHOD: VISUAL TESTING LEVEL: 1**

### **SUBJECT: 4. EQUIPMENT AND ACCESSORIES**

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#### CONTENTS:

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- 4.1 Instruments for illumination
  - 4.1.1 Different types of light sources; efficiency and useful life
  - 4.1.2 Auxiliary equipment for light sources: tripod supports, transformers, filters, collimators, etc
  - 4.1.3 Sources of non-visible radiation; ultraviolet, infrared lamps, filters
- 4.2 Visual aids
  - 4.2.1 Lenses, prisms and mirrors, characteristics of construction
  - 4.2.2 Optical systems; microscopes, telescopes, projectors, characteristics of construction, optical holographic methods, automated visual inspection and magnifier
  - 4.2.3 Micro-alignment telescope and accessories
  - 4.2.4 Gauges and measuring devices
- 4.3 Image transmitting instruments

- 4.3.1 Instruments for optical transmission of images; rigid and flexible endoscopes, characteristics of construction
- 4.3.2 Combination equipment for the transmission of images; optical equipment coupled to TV systems [C.C.T.V.]
- 4.3.3 Digital camera
- 4.4 Equipment for monitoring
- 4.4.1 Optical vibration monitoring equipment
- 4.5 In-situ metallography

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SPECIFIC OBJECTIVES:

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- 4.1 Given the instructor's explanations, the student will be able to:
  - a) list different types of light sources and give reference to efficiency and useful life;
  - b) list ancillary equipment normally used with light sources;
  - c) describe ultraviolet lamps.
- 4.2 Given the instructor's explanations, the student will be able to:
  - a) describe lenses, prisms and mirrors;
  - b) describe different optical systems employed in T.V.
- 4.3 Given the instructor's explanations, the student will be able to:
  - a) describe construction and operation of rigid endoscopes;
  - b) describe construction and operation of flexible endoscopes;
  - c) describe the use of different vision angles in endoscopes;
  - d) describe T.V. systems.
- 4.4 Given the instructor's explanations, the student will be able to explain different types of monitoring equipment.
- 4.5 Given the instructor's explanations, the student will be able to explain the process of insitu metallography.

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including demonstration and student practical work.

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EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos, course notes,  
Light sources,  
Visual aids,  
Instruments mentioned above.

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

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CONTENTS:

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- 5.1 Surface preparation for the examination
- 5.2 Observation techniques
  - 5.2.1 Direct visual examination
  - 5.2.2 Remote visual examination
  - 5.2.3 Translucent visual examination
- 5.3 Illumination conditions dependent on type of surface to be examined and expected defects
- 5.4 Evaluation of visual acuity, use of Jaeger chart, qualification of the examination using reference samples
- 5.5 Inspection characteristics and scope of tests
  - 5.5.1 General VT; checking general condition, first impression of test piece e.g. identification, set up.

5.5.2 Specific VT; testing for specific characteristics requiring higher level of illumination and equipment, e.g. deviation in shape, surface texture, defects

5.6 Data recording

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SPECIFIC OBJECTIVES:

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- 5.1 Given the instructor's explanations, the student will be able to describe the surface preparation for visual examination.
  - 5.2 Given the instructor's explanations, the student will be able to list the different techniques applied in visual examination.
  - 5.3 Given the instructor's explanations, the student will be able to describe different illumination conditions depending on the surface to be examined.
  - 5.4 Given the instructor's explanations, the student will be able to describe the use of the Jaeger chart and reference samples.
  - 5.5 Given the instructor's explanations, the student will be able to produce a record of data concerning a special visual test.
  - 5.6 Given the instructor's explanations, the student will be able to operate test equipment using techniques following test instructions.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Slides, Power Point/Transparencies, Slides/Videos, writing board, course notes, Jaeger charts, and sample pieces.

**INSPECTION METHOD: VISUAL TESTING LEVEL: 1**

**SUBJECT: 6. IMAGE RECORDING**

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CONTENTS:

- 
- 6.1 Photographic recording
    - 6.1.1 Main characteristics and fundamentals of photographic cameras
    - 6.1.2 Different types of films
  - 6.2 Replication; conditioning techniques for observation and special requirements for surface preparation
  - 6.3 Film digitization and image processing

---

SPECIFIC OBJECTIVES:

- 
- 6.1 Given the instructor's explanations, the student will be able to:
    - a) describe the main characteristics of photographic cameras;
    - b) describe the common films used in visual inspection.
  - 6.2 Given the instructor's explanations, the student will be able to describe the different techniques used to produce a replica and the special requirements for surface preparation.
  - 6.3 Given the instructor's explanations, the student will be able to describe film digitization and image processing.
-

METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Power Point/Transparencies, Slides/Videos, Writing board  
Course notes,  
Replica samples,  
Photographic cameras and Photographic films.

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

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CONTENTS:

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- 7.1 General knowledge
    - 7.1.1 National, regional and international codes and standards
    - 7.1.2 General knowledge of specifications
  - 7.2 Instructions for the test
    - 7.2.1 Interpretation
- 

SPECIFIC OBJECTIVES:

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- 7.1 Given the instructor's explanations and various classifications of visual examination processes in accordance with standards, the student will be able to prepare a table classifying the techniques in accordance with various standards, explaining the relationship between them.
  - 7.2 Given the instructor's explanations and written instructions, the student will be able to:
    - a) interpret the instructions and perform the test correctly;
    - b) fill out the test forms and note the results.
- 

METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, and Slides/Videos  
Codes,  
Standards and specifications,  
Test samples,  
Course notes.

# **INSPECTION METHOD: VISUAL TESTING LEVEL: 1**

## **SUBJECT: 8. SAFETY ASPECTS**

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### CONTENTS:

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- 8.1 Safety and environmental consideration
  - 8.1.1 Safety for visual and optical tests
    - a) Need for safety
    - b) Laser hazards
    - c) Infrared hazards
    - d) Ultraviolet hazards
    - e) Photosensitizers
    - f) Damage to the retina
    - g) Thermal factor
    - h) Blue hazards
    - i) Eye protection filters
  - 8.2 Industrial safety standards
  - 8.3 Visual and optical testing environment
    - a) Cleanliness
    - b) Texture and reflectance
    - c) Lighting for V.T.
    - d) Light intensities
    - e) Vision in the testing environment
  - 8.4 Visual safety environment
- 

### SPECIFIC OBJECTIVES:

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- 8.1 Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out.
  - 8.2 Given the instructor's explanations, the student will be able to apply good safety practices in the application of visual testing.
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### METHODOLOGICAL STRATEGIES:

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Instructor's presentation including guided discussion and practical workshop.

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### EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos,  
Course notes,  
Safety standards,  
Safety equipment & accessories.



# **INSPECTION METHOD: VISUAL TESTING LEVEL: 1**

## **SUBJECT: 9. APPLICATIONS**

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### CONTENTS:

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- 9.1 Applications: VT during manufacturing process
  - 9.1.1 Applications of visual and optical tests in the electric power industries Joining processes, acceptance standards, recording and reporting visual test results
  - 9.1.2 Specific visual inspection applications Pumps, valves, bolting, forging, rolled stock and casting.
  - 9.1.3 Applications of visual and optical tests in the transportation industries Optical tests in the automobile industries, optically aided visual testing of aircraft structure.
  - 9.2 Interface of visual testing with other NDT methods Visual testing of liquid penetrant, leak testing, radiographic testing, magnetic particle testing, ultrasonic testing & etc.
  - 9.3 Applications of photography in visual testing Photographs as a permanent record for VT, photogrammetry for documenting the condition of petrochemical furnaces conclusions.
  - 9.4 Visual testing of ceramics
  - 9.5 Visual testing of threads in oil country tubular goods
  - 9.6 Visual testing of composite materials
  - 9.7 Visual testing of micro-electronic components
  - 9.8 In-service Inspection
  - 9.8.1 ISI of plants in the light of call up maintenance card
  - 9.8.2 Displacement measurement of moving parts of equipments i.e. pumps compressor, motor & etc.
  - 9.8.3 Optical techniques for vibration monitoring
    - a) Static measurement
    - b) Dynamic measurement
- 

### SPECIFIC OBJECTIVES:

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Given the instructor's explanations, the student will be able to understand different applications of different visual testing techniques.

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### METHODOLOGICAL STRATEGIES:

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Instructor's presentation including guided discussion and practical workshop.

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### EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

### **SUBJECT: 1. GENERAL KNOWLEDGE**

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#### CONTENTS:

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- 1.1 Basic principles of NDT
    - 1.1.1 Definitions and methodology of applications of basic methods; VT, PT, MT, RT, UT, ET,
    - 1.1.2 Fields of application of common methods
    - 1.1.3 Range and limitations of common methods, including the subject method
    - 1.1.4 New developments in NDT
    - 1.1.5 Responsibilities of levels of certification
  - 1.2 Materials
    - 1.2.1 Physical and mechanical properties of materials (metallic and non-metallic)
    - 1.2.2 Structures of metals and alloys
    - 1.2.3 Indications, discontinuities and defects
    - 1.2.4 In-service and manufacturing discontinuities
- 

#### SPECIFIC OBJECTIVES:

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- 1.1 Given the instructor's explanations, the student will be able to:
    - a) define non-destructive testing;
    - b) describe the basic principles and the method of application of the common NDT methods;
    - c) discuss the best applications, limitations and problems relating to the use of each method.
  - 1.2 Given the instructor's explanations, the student will be able to:
    - a) describe the structure, physical and mechanical properties of metallic materials
    - b) describe the various types of discontinuities and defects, their sources and their classification.
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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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Transparencies  
Slides  
Films  
Writing board  
Course notes

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## **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

### **SUBJECT: 1. GENERAL KNOWLEDGE**

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#### CONTENTS:

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- 1.3 Processing and defects
  - 1.3.1 Primary processes and related defects
  - 1.3.2 Manufacturing processes and related defects:
    - a) casting processes and associated discontinuities: Ingots, blooms, and billets; Sand casting; Centrifugal casting; Investment casting
    - b) wrought processes and associated discontinuities: forgings; rolled products; extruded products

c) welding processes and associated discontinuities: submerged arc welding (SAW); shielded metal arc welding (SMAW); gas metal arc welding (GMAW); flux cored arc welding (FCAW); gas tungsten arc welding (GTAW); resistance welding; special welding processes — electron beam, electrogas, etc.

1.4 Materials in service

1.4.1 Behaviour of materials in service

1.4.2 Service conditions leading to defects and failures: corrosion; creep; fatigue; wear; overload; brittle fracture, erosion, others

1.4.3 Concepts of rupture development in metals

1.5 Quality and standardization

1.5.1 Definition of quality, quality control and standardization

1.5.2 Development of a quality system

1.5.3 Examination, testing and inspection

1.5.4 Standards, codes, specifications and procedures

1.5.5 Protocols, records and reports

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#### SPECIFIC OBJECTIVES:

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

- a) describe the common primary metallurgical processes and the related defects;
- b) describe the common manufacturing processes and the related defects.

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

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

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

- a) describe the basic concepts of quality and standardization;
- b) list the basic elements of a quality system;
- c) explain the basic premise of administration of information in a quality system.

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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

Transparencies

Films slides

Writing board

Course notes

Samples of materials and defects

Typical documents, i.e. codes

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#### **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

#### **SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST**

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#### CONTENTS:

2.1 Fundamentals of visual and optical testing

2.1.1 Description of visual and optical test

2.1.2 Luminous energy test, geometrical optics, image formation, light sources, stroboscopic sources, light detection and recording, fluorescence detection

2.2 Nature of light

- a) Wave theory
  - b) Quantum theory
  - 2.2.1 Electromagnetic radiations; light spectra, infrared and ultraviolet radiation
  - 2.2.2 Characteristics of light; intensity and colour
  - 2.2.3 Magnitudes and units
  - 2.2.4 Measurement
  - 2.3 Basic laws of the phenomena of regular and diffuse reflection, refraction, dispersion, diffraction, absorption, and transmission of light
  - 2.4 Emissivity and reflectance
- 

#### SPECIFIC OBJECTIVES:

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- 2.1 Given the instructor's explanations, the student will be able to:
    - a) list the properties of light;
    - b) establish the characteristics of the electromagnetic spectrum;
    - c) establish the limits of the visible spectrum.
  - 2.2 Given the instructor's explanations, the student will be able to:
    - a) define the sources of equal intensity;
    - b) define luminous flux;
    - c) establish the variations of the light with the distance;
    - d) define different units of illumination.
  - 2.3 Given the instructor's explanations, the student will be able to:
    - a) define laws of reflection and refraction;
    - b) understand the concept of dispersion, diffraction, absorption, transmission of light
  - 2.4 Given the instructor's explanations, the student will be able to establish the relation between emissivity and reflectance.
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#### METHODOLOGICAL STRATEGIES:

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Instructor's presentation including lectures, guided discussions and review of examples including simple calculations.

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#### EQUIPMENT AND RESOURCES:

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Power Point/Transparencies, Slides/Videos, course notes, and writing board.

## **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

## **SUBJECT: 3. VISION**

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#### CONTENTS:

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- 3 Vision
  - 3.1 Human eye, the anatomical and physical aspects of the eye
    - 3.1.1 Formation of the image
    - 3.1.2 Perception of intensity and colour
    - 3.1.3 Separation ability
    - 3.1.4 Visual acuity
  - 3.2 Reaction of the eye to excitation
    - 3.2.1 Adaptation, reaction to glare
    - 3.2.2 Distance and relief perception (stereoscopic perception)
    - 3.2.3 Perception of contrast and colour
    - 3.2.4 Threshold levels of intensity
  - 3.3 Vision defects

- 3.3.1 Types of blindness; night blindness; day blindness; colour blindness
- 3.3.2 Symptomatic disturbance
  - a) Partial loss of vision
  - b) Complete loss of vision
- 3.3.3 Injuries
  - a) Thermal injuries
  - b) Electrical injuries
  - c) Radiation injuries

---

SPECIFIC OBJECTIVES:

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- 3.1 Given the instructor's explanations, the student will be able to:
  - a) identify the main components of the human eye;
  - b) explain image formation;
  - c) separation ability;
  - d) define visual acuity;
  - e) explain how the eye perceives the difference between intensity and color;
- 3.2 Given the instructor's explanations, the student will be able to:
  - a) develop the concepts of illumination and luminance;
  - b) explain the concept of stereoscopic vision;
  - c) list and explain visual defects;
  - d) understand the levels of intensity and color.

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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

## **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

### **SUBJECT: 4. EQUIPMENT AND ACCESSORIES**

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CONTENTS:

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- 4.1 Instruments for illumination
  - 4.1.1 Source of visible radiation, spectral quality, efficiency and useful life
  - 4.1.2 Classification of the sources
    - a) Continuous
    - b) Flash
    - c) Incandescent
    - d) Discharge
    - e) Fluorescent
    - f) Electronic flash
  - 4.1.3 Ancillary equipment for light sources
    - a) Tripod supports
    - b) Transformers
    - c) Filters
    - d) Collimators, etc.
  - 4.1.4 Types of illumination; directional; diffused; secondary
  - 4.1.5 Sources of non-visible radiation, ultraviolet, infrared, filters

- 4.2 Machine vision technology
- 4.2.1 Lighting techniques, optical filtration, image processing
- 4.2.2 Image segmentation
- 4.2.3 Temperature indicating material
- 4.2.4 Chemical aids

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SPECIFIC OBJECTIVES:

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- 4.1 Given the instructor's explanations, the student will be able to:
  - a) know the sources in terms of the spectral quality of the radiation;
  - b) know the efficiency and useful life of the sources;
  - c) classify different types of sources;
  - d) identify sources based on the construction characteristics;
  - e) recognize the use of various accessories for illumination systems;
  - f) ensure control requirements for result repeatability.
- 4.2 Given the instructor's explanations, the student will be able to describe the use of machine vision technology and associated aids

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Power Point/Transparencies, Slides/Videos, sample pieces, auxiliary equipment, course notes, writing board, light sources, light transmitting equipment, and visual aids.

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

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CONTENTS:

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- 4.3 Visual aids
- 4.3.1 Lenses, prisms, mirrors, characteristics of construction
- 4.3.2 Microalignment telescope, principle and accessories
- 4.3.3 Optical systems, microscopes, telescopes, projectors, characteristics of construction, Image transmitting instruments, optical holographic methods, automated visual inspection
- 4.3.4 Gauges and measuring devices
- 4.4 Image transmitting instruments
- 4.4.1 Instruments for optical transmission of images, rigid and flexible endoscope, periscope, basic principles and operations of image transmitting instruments and their construction characteristics.
- 4.4.2 Combination equipment for the transmission of images: optical equipment coupled to T.V. systems. Basic principles and operation, construction characteristics, scope and limitations; Digital cameras
- 4.5 Optical equipment for monitoring vibration
- 4.6 In-situ metallography

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SPECIFIC OBJECTIVES:

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- 4.3 Given the instructor's explanations, the student will be able to:
  - a) list the main optic laws;
  - b) apply those laws with simple calculations;
  - c) define lenses, prisms, mirrors, characteristics;
  - d) recognize different optical systems and describe their method of operation;

- e) recognize the range of application and limitations of the equipment.
- 4.4 Given the instructor's explanations, the student will be able to:
  - a) recognize and describe image transmitting equipment;
  - b) operate and understand the operation characteristics;
  - c) select equipment suitable to requirements;
  - d) use schemes to explain combination systems of image transmission;
  - e) know the applications of T.V. systems.
- 4.5 Given the instructor's explanations, the student will be able to operate basic optical vibration monitoring equipment
- 4.6 Given the instructor's explanations, the student will be able to take surface replicas for in-situ metallography

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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Power Point/Transparencies, Slides/Videos, light transmitting equipment, course notes, light sources, ancillary equipment, visual aids, sample pieces, and Writing board.

## **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

### **SUBJECT: 5. WORK PARAMETERS AND CONDITIONS**

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CONTENTS:

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- 5.1 Surface preparation for examination
  - 5.2 Observation techniques
    - 5.2.1 Direct visual examination
    - 5.2.2 Remote visual examination
  - 5.3 Illumination conditions dependent on type of surface to be examined and expected defects
  - 5.4 Evaluation of visual acuity, use of Jaeger chart and reference samples
  - 5.5 Presentation of results to be used in analysis, documentation and filing
  - 5.6 Visual and optical testing procedures
- 

SPECIFIC OBJECTIVES:

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- 5.1 Given the instructor's explanations, the student will be able to describe the surface preparation for visual examination.
  - 5.2 Given the instructor's explanations, the student will be able to list the different techniques applied in visual examination.
  - 5.3 Given the instructor's explanations, the student will be able to:
    - a) describe different illumination conditions dependent on the surface to be examined;
    - b) select appropriate equipment dependent on different conditions and choose a technique suitable for the actual test problem, define its scope, field of application and limitations.
  - 5.4 Given the instructor's explanations, the student will be able to describe the use of the Jaeger chart and reference samples.
  - 5.5 Given the instructor's explanations, the student will be able to:
    - a) produce a record of data concerning a specific visual test;
    - b) translate the data in a report to analyze, document and file;
    - c) write instructions sheet.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Power Point/Transparencies, Slides/Videos, course notes, writing board, sample pieces, and Jaeger charts.

**INSPECTION METHOD: VISUAL TESTING LEVEL: 2**  
**SUBJECT: 6. IMAGE RECORDING**

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CONTENTS:

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- 6.1 Photographic recording
    - 6.1.1 Main characteristics and fundamentals of photographic cameras
    - 6.1.2 Different types of film
  - 6.2 Replicas, different techniques, conditioning for observations
  - 6.3 Film digitization and image processing
- 

SPECIFIC OBJECTIVES:

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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Power Point/Transparencies, Slides/Videos, Course notes, Writing board,  
Photographic cameras and Photographic films,  
Replicas, Replica materials,  
Sample pieces.



## **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

### **SUBJECT: 7. CODES, STANDARDS, SPECIFICATIONS AND PROCEDURES**

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#### CONTENTS:

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- 7.1 General knowledge and overview of codes and standards
    - 7.1.1 General knowledge of specifications and procedures
    - 7.1.2 Interpretation of procedures and compilation of test instructions
  - 7.2 Performance of test in accordance with written instructions
    - 7.2.1 Records of operating conditions on test forms
    - 7.2.2 Evaluation of tasks carried out by level 1 operators
  - 7.3 Instructions for testing in special situations
    - 7.3.1 Range of application of the test, equipment and technique
    - 7.3.2 Visual testing acceptance criteria for welds
- 

#### SPECIFIC OBJECTIVES:

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- 7.1 Given the instructor's explanations and testing procedures, the student will be able to:
    - a) demonstrate understanding of the significance and application of codes, standards, specifications and procedures;
    - b) recognize various standards existing for the application of visual inspection;
    - c) prepare instructions for testing, describing all steps to be followed to perform the test.
  - 7.2 Given the instructor's explanations, the student will be able to establish and evaluate tasks for level 1 personnel.
  - 7.3 Given the instructor's explanations, the student will be able to formulate instructions for testing under special conditions and according to requirement of standards adopted for the actual working conditions.
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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, and Slides/Videos  
Codes, Standards (ASME, ASTM, DIN, API, BSI, COVENIN, JIS),  
Forms for data registration,  
Test procedures and examples of written instructions,  
Work pieces,  
Equipment and accessories.

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## **INSPECTION METHOD: VISUAL TESTING LEVEL: 2**

### **SUBJECT: 8. SAFETY ASPECTS**

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#### CONTENTS:

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- 8.1 Safety and environmental consideration
  - 8.1.1 Safety for visual and optical tests
    - a) Need for safety
    - b) Laser hazards
    - c) Infrared hazards

- d) Ultraviolet hazards
- e) Photosensitizers
- f) Damage to the retina
- g) Thermal factor
- h) Blue hazards
- i) Eye protection filters
- 8.2 Industrial safety standards
- 8.3 Visual and optical testing environment
  - a) Cleanliness
  - b) Texture and reflectance
  - c) Lighting for V.T.
  - d) Light intensities
  - e) Vision in the testing environment
- 8.4 Visual safety recommendations

SPECIFIC OBJECTIVES:

- 8.1 Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out.
- 8.2 Given the instructor's explanations, the student will be able to apply good safety practices in the application of visual testing.

METHODOLOGICAL STRATEGIES:

Instructor's presentation including guided discussion and practical workshop.

EQUIPMENT AND RESOURCES:

Writing board, Power Point/Transparencies, Slides/Videos,  
 Course notes,  
 Safety standards,  
 Safety equipment & accessories.

**INSPECTION METHOD: VISUAL TESTING LEVEL: 2**  
**SUBJECT: 9. APPLICATIONS**

CONTENTS:

- 9.1 Applications: VT during manufacturing process
  - 9.1.1 Applications of visual and optical tests in the electric power industries
  - 9.1.2 Joining processes, acceptance standards, recording and reporting visual test results
  - 9.1.3 Specific visual inspection applications, pumps, valves, bolting, forging, rolled stock and casting
  - 9.1.4 Applications of visual and optical tests in the transportation industries, optical tests in the automobile industries, optically aided visual testing of aircraft structure
- 9.2 Interface of visual testing with other NDT methods.; visual testing of liquid penetrant, leak testing, radiographic testing, magnetic particle testing, ultrasonic testing etc.
- 9.3 Applications of photography in visual testing; photographs as a permanent record, photogrammetry for documenting the condition of petrochemical furnaces
- 9.4 Visual testing of ceramics
- 9.5 Visual testing of threads in oil industry tubular goods
- 9.6 Visual testing of composite materials
- 9.7 Visual testing of microelectronic components
- 9.8 Visual and optical testing in metal industry
- 9.9 In-service inspection
  - 9.9.1 ISI of plants in the light of call up maintenance card
  - 9.9.2 Displacement measurement of moving parts of the components i.e. pumps, compressors, motors, etc.

9.9.3 Optical vibration monitoring

- a) Static measurement
- b) Dynamic measurement

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SPECIFIC OBJECTIVES:  
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Given the instructor's explanations, the student will be able to understand different applications of different visual testing techniques.

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METHODOLOGICAL STRATEGIES:  
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Instructor's presentation including guided discussion and practical workshop.

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EQUIPMENT AND RESOURCES:  
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Writing board, Power Point/Transparencies, Slides/Videos, and Course notes.

## **INSPECTION METHOD: VISUAL TESTING LEVEL: 3**

### **SUBJECT: 1. GENERAL KNOWLEDGE**

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CONTENTS: SEE BASIC LEVEL 3 SYLLABUS

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## **INSPECTION METHOD: VISUAL TESTING LEVEL: 3**

### **SUBJECT: 2. PHYSICAL PRINCIPLES OF THE TEST**

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CONTENTS:

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- 2.1 Electromagnetic radiations
    - 2.1.1 Characteristics of luminous spectra; intensity, colour, tone and frequency
    - 2.1.2 Luminous sources; intensity of the luminous sources, photometric and radiometric measurements, illumination, luminous flux and luminance; experimental law of photometry
    - 2.1.3 Fundamental laws for emission, transmission and absorption of light, interface phenomena, emissivity and reflectance
    - 2.1.4 Role, importance and scheduling of visual testing
    - 2.1.5 Geometrical optics, distortion, measurement
    - 2.1.6 Errors of refraction and means of correction
      - a) Myopia or short-sightedness, concave spherical glasses
      - b) Hypermetropia or long sightedness, convex spherical glasses
      - c) Astigmatism cylindrical lenses or contact lenses
- 

SPECIFIC OBJECTIVES:

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- 2.1 Given the instructor's explanations, the student will be able to:
    - a) describe the properties of light;
    - b) establish the characteristics of the electromagnetic spectra;
    - c) establish the range of the spectra corresponding to light;
    - d) define luminous sources of equal intensity;
    - e) define luminous flux;
    - f) explain the experimental law of photometry;
    - g) define the different units of illumination;
    - h) define the phenomena occurring when light passes through an interface;
    - i) explain concepts related to dispersion, diffraction, absorption and transmission of light;
    - j) explain emissivity and reflectance.
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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including an analysis of the graphic expression of application rules and principles, guided discussion and laboratory experiments.

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EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos, Tables and drawings Laboratory material to demonstrate physico-chemical principles and Course notes.

# **INSPECTION METHOD: VISUAL TESTING LEVEL: 3**

## **SUBJECT: 3. VISION**

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### CONTENTS:

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- 3.1 Vision
    - 3.1.1 Human eye; principal physiological and anatomical aspects, focus and resolution
    - 3.1.2 Response of eye to luminous excitation, spectral sensitivity, perception of intensity, color and contrast, stereoscopic vision
    - 3.1.3 Sensitivity thresholds, visual acuity, contrast and colour sensitivity, influence of intensity and luminance
    - 3.1.4 Defects of vision
  - 3.2 Fundamentals of optical physics applied to lenses, mirrors, prisms and optical systems
  - 3.3 Types of blindness
    - a) Night blindness
    - b) Day blindness
    - c) Colour blindness
  - 3.4 Symptomatic disturbance
    - a) Partial loss of vision
    - b) Complete loss of vision
  - 3.5 Injuries
    - a) Thermal injuries
    - b) Electrical injuries
    - c) Radiation-induced injuries
- 

### SPECIFIC OBJECTIVES:

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- 3.1 Given the instructor's explanations, the student will be able to:
    - a) identify the different parts of the human eye explaining their functions;
    - b) explain separation power and visual acuity;
    - c) explain perception of intensity, colour and contrast;
    - d) explain concepts of intensity and luminance;
    - e) explain the stereoscopic viewing of the eye and near and far vision;
    - f) explain the different possible defects of vision.
  - 3.2 Given the instructor's explanations, the student will be able to:
    - a) explain the fundamental laws of optics;
    - b) explain the main characteristics of types of lenses, prisms, mirrors and optical systems.
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### METHODOLOGICAL STRATEGIES:

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Instructor's presentation including lecture and solution of problems.

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### EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos, course notes, optical devices and aids.

# **INSPECTION METHOD: VISUAL TESTING LEVEL: 3**

## **SUBJECT: 4. EQUIPMENT AND ACCESSORIES**

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### CONTENTS:

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- 4.1 Illumination sources
  - 4.1.1 Various types of illumination sources, various fixing apparatus and various accessories. Sources for polarized light
  - 4.1.2 Lamps for ultraviolet radiation, lasers
  - 4.1.3 Accessories for filtering and collimating light beam, measuring instruments for measuring light intensity (luximeters)
- 4.2 Visual aids; lenses, prisms, mirrors, compound lenses, stereoscopic loops, optical microscope, telescope and projectors
- 4.3 Image transmission
  - 4.3.1 Fiber optics, acrylic and glass-fibers, transmission of image and transmission of light
  - 4.3.2 Rigid and flexible endoscopes, endoscopes with micro T.V. systems block diagram
- 4.4 Micro alignment telescope
- 4.5 Digital camera
- 4.6 Equipment for monitoring
  - a) Real time monitoring equipment
  - b) mobile monitoring equipment
  - c) vibration properties of materials
  - d) vibration characteristics of structure
  - e) methods for measuring the frequency

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### SPECIFIC OBJECTIVES:

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- 4.1 Given the instructor's explanations, the student will be able to:
  - a) explain values of light source emitters according to spectral quality of the radiation;
  - b) explain the efficient and useful life of different sources of light;
  - c) explain principles of operation and construction of various light sources;
  - d) recognize the usefulness of various accessories for controlling light sources.
- 4.2 Given the instructor's explanations, the student will be able to:
  - a) explain the characteristics of lenses, prisms and other optical systems;
  - b) explain characteristics of compound lenses, stereoscopic loops, microscopes, telescopes and projectors;
  - c) select the suitable equipment for the test.
- 4.3 Given the instructor's explanations, the student will be able to:
  - a) explain construction characteristics of various types of endoscopes; explain the combined system for image transmission; explain the applications of T.V. systems.
- 4.4 Given the instructor's explanations, the student will be able to explain the construction and use of a micro alignment telescope.
- 4.5 Given the instructor's explanations, the student will be able to explain the working of a digital camera.
- 4.6 Given the instructor's explanations, the student will be able to explain various types of monitoring equipment.

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### METHODOLOGICAL STRATEGIES:

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

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### EQUIPMENT AND RESOURCES:

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

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

## **INSPECTION METHOD: VISUAL TESTING LEVEL: 3**

### **SUBJECT: 5. WORK PARAMETERS AND CONDITIONS**

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#### CONTENTS:

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- 5.1 Surface preparation
  - 5.2 Illuminating conditions, intensity, angle, distance, type of illumination
  - 5.3 Viewing techniques; direct, indirect and image transmission
    - 5.3.1 Parameters for the selection and operation of the various techniques
  - 5.4 Programming the sequences of viewing, systems for identification of the areas to be examined, assessing relevance of features to be detected, evaluation of features against fitness-for-purpose aspects
  - 5.5 Control and calibration of the test
    - 5.5.1 Jaeger charts for the control of near and far vision, JIS charts for colour blindness
    - 5.5.2 Reference blocks with calibrations, reference block with cracks ,control of perceptibility in accordance with procedures
    - 5.5.3 Maintenance and control of equipment and accessories, calibration of luximeter or photometer, specific objectives
  - 5.6 Rules for the use, maintenance and control for equipment and accessories, work in the laboratory and in the field
  - 5.7 Visual and optical test procedures
  - 5.8 Selection and specification of equipment for the test
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#### SPECIFIC OBJECTIVES:

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

- a) establish all necessary preparations of surface for test;
  - b) establish at selected necessary parameters related to illumination, angle, distance, etc., needed to perform the test;
  - c) establish the technique to be applied;
  - d) establish the sequence of operation and system of identification for the test;
  - e) explain the use of Jaeger and JIS charts; procedure writing;
  - f) explain the use of reference blocks for the control of perceptibility;
  - g) establish rules for the use, maintenance and control of equipment and accessories;
  - h) calibrate luximeter and photometers;
  - i) select all equipment necessary to perform a specific test;
  - j) assist and advise in drafting acceptance criteria.
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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos, course notes, sample pieces, light sources, Jaeger and JIS charts, and reference blocks.

**INSPECTION METHOD: VISUAL TESTING LEVEL: 3**  
**SUBJECT: 6. IMAGE RECORDING**

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CONTENTS:

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- 6.1 Photographic recording
    - 6.1.1 Fundamentals of photography and photographic cameras
    - 6.1.2 Various types of photographic cameras. Macro and telephotography.
    - 6.1.3 Various types of film. Spectral sensitivity. Contrast, latitude and grain
  - 6.2 Replicas
    - 6.2.1 Various types of replica: positive and negative, macro and micro resolutions
    - 6.2.2 Materials employed on the different techniques
    - 6.2.3 Conditioning of replicas and requirements for their observation and conservation
  - 6.3 Film digitization and image processing.
- 

SPECIFIC OBJECTIVES:

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- 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
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos,  
Course notes,  
Various types of cameras,  
Replicas, Replica materials and Sample pieces.

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

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CONTENTS:

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- 7.1 Examination specifications
    - 7.1.1 Function of design engineering
    - 7.1.2 Design and building codes
    - 7.1.3 ASME code (or other equivalent codes)
  - 7.2 Standards specific to visual inspection
    - 7.2.1 National and international standards (ASTM, DIN, MIL, IRAM)
    - 7.2.2 Interpretation of specifications, codes and standards
  - 7.3 Testing procedures
    - 7.3.1 Formulation of test procedures
    - 7.3.2 General and specific procedures
  - 7.4 General rules for safety in industrial establishments
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SPECIFIC OBJECTIVES:



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- 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.
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METHODOLOGICAL STRATEGIES:

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

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EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos,  
Codes (ASME, ASTM, DIN, API, BSI, JIS, etc.),  
Formulae for data registration,  
Work pieces,  
Test procedures and examples of written instructions.

**INSPECTION METHOD: VISUAL TESTING LEVEL: 3**  
**SUBJECT: 8. SAFETY ASPECTS**

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CONTENTS:

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- 8.1 Safety and environmental consideration
    - 8.1.1 Safety for visual and optical tests
      - a) Need for safety
      - b) Laser hazards
      - c) Infrared hazards
      - d) Ultraviolet hazards
      - e) Photosensitizers
      - f) Damage to the retina
      - g) Thermal factor
      - h) Blue hazards
      - i) Eye protection filters
    - 8.2 Industrial safety standards
    - 8.3 Visual and optical testing environment
      - a) Cleanliness
      - b) Texture and reflectance
      - c) Lighting for V. T.
      - d) Light intensities
      - e) Vision in the testing environment
    - 8.4 Visual safety recommendations
    - 8.5 Implementation of industrial safety standards in facilities and equipment and in their operation
    - 8.6 Hazards of using toxic and inflammable materials
    - 8.7 Materials, accessories and equipment for the protection of persons and facilities
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SPECIFIC OBJECTIVES:

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Given the instructor's explanations, the student will be able to describe the safety conditions under which the test should be carried out and be able to apply good safety practices.

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including guided discussion and practical workshop.

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EQUIPMENT AND RESOURCES:

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Writing board, Power Point/Transparencies, Slides/Videos,  
Course notes  
Safety standards  
Safety equipment & accessories.

**INSPECTION METHOD: VISUAL TESTING LEVEL: 3**  
**SUBJECT: 9. APPLICATIONS**

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CONTENTS:

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- 9.1 Applications; VT during manufacturing process
  - 9.1.1 Applications of visual and optical tests in the electric power industries
  - 9.1.2 Joining processes, acceptance standards, recording and reporting visual test results
  - 9.1.3 Specific visual inspection applications, pumps, valves, bolting, forging, rolled stock and casting
  - 9.1.4 Applications of visual and optical tests in the transportation industries, optical tests in the automobile industries, optically aided visual testing of aircraft structure
  - 9.2 Interface of visual testing with other NDT methods, visual testing of liquid penetrant, leak testing, radiographic testing, magnetic particle testing, ultrasonic testing, etc.
  - 9.3 Applications of photography in visual testing, photographs as a permanent record, photogrammetry for documenting the condition of petrochemical furnaces conclusions
  - 9.4 Visual testing of ceramics
  - 9.5 Visual testing of threads in oil industry tubular goods
  - 9.6 Visual testing of composite materials
  - 9.7 Visual testing of micro electronic components
  - 9.8 Visual and optical testing in metal industry
  - 9.9 In-service inspection
    - 9.9.1 ISI of plants in the light of call up maintenance card
    - 9.9.2 Displacement measurement of moving parts of the components i.e. pumps compressors, motors, etc.
    - 9.9.3 Optical vibration monitoring
      - a) Static measurement
      - b) Dynamic measurement

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SPECIFIC OBJECTIVES:

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Given the instructor's explanations, the student will be able to understand different applications of different visual testing techniques.

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METHODOLOGICAL STRATEGIES:

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Instructor's presentation including guided discussion and practical workshop.

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EQUIPMENT AND RESOURCES:

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

## **BASIC – Level 3**

# **BASICS - GENERAL KNOWLEDGE LEVEL: 3**

## **SUBJECT: 1. NDT, MATERIALS AND PROCESSES**

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### CONTENTS:

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- 1 NDT Methods
  - 1.1 Basic knowledge of at least 4 NDT methods at level 2 (MT/PT/RT/UT/VT)
    - 1.1.1 Scope and limitations: comparison of different NDT methods
    - 1.1.2 Selection of methods
  - 1.2 Technology of materials
    - 1.2.1 Discontinuities and defects in materials. Classification according to location and morphology
    - 1.2.2 Properties of materials
    - 1.2.3 Nature of materials and solid state changes in materials
    - 1.2.4 Phase Diagram and allotropy, ferrous metals
    - 1.2.5 Non-ferrous metals and plastics
    - 1.2.6 Nature of manufacturing
    - 1.2.7 Casting process
    - 1.2.8 Welding process
    - 1.2.9 Rolling process
    - 1.2.10 Forging process
    - 1.2.11 Powder metallurgy
    - 1.2.12 Machining fundamentals
    - 1.2.13 miscellaneous processes
    - 1.2.14 Mechanism of in-service defect formation (corrosion, wear, tear, fatigue crack, creep, hydrogen embrittlement, stress corrosion cracking, etc)
    - 1.2.13 Surface finishing
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### SPECIFIC OBJECTIVES:

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

## **BASIC - GENERAL KNOWLEDGE LEVEL: 3**

### **SUBJECT: 2. QUALITY ASSURANCE AND STANDARDIZATION**

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#### CONTENTS:

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- 2.1 Quality assurance
    - 2.1.1 Basic principles for the application of quality assurance
    - 2.1.2 Organization of quality assurance, Quality manual, Quality control, Auditing of quality.
    - 2.1.3 Management and control of quality assurance documentation, quality control of testing
    - 2.1.4 Certification and accreditation of NDT facilities
    - 2.1.5 Reports on testing, documentation systems
  - 2.2 Standardization
    - 2.2.1 Definition of standardization, principles for writing of standards
    - 2.2.2 Codes, standards, specification procedures and instructions
    - 2.2.3 Procedure Writing, i.e format, structure, and content of procedures
    - 2.2.4 Procedure validation
  - 2.3 Reports and protocols
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#### SPECIFIC OBJECTIVES:

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- 2.1 Given the instructor's explanations, the student will be able to:
    - a) interpret and apply quality assurance procedures to the application of NDT at all stages;
    - b) analyze, evaluate and prepare all testing documentation in accordance with the requirements of quality assurance;
    - c) define requirements for quality assurance in the specific area of activity;
    - d) understand the difference between certification and accreditation;
    - e) implement certification and accreditation processes.
  - 2.2 Given the instructor's explanations, the student will be able to:
    - a) define standardization and discuss basic principles for writing of standards;
    - b) discuss the benefit and applications of standards, codes, specifications and procedures;
  - 2.3 Given the instructor's explanations, the student will be able to:
    - a) explain the difference between codes, standards, specification, procedures, and instructions;
    - b) select the information necessary to write a procedure related to codes and standards
  - 2.4 Given the instructor's explanations, the student will be able to write the table of contents of a procedure and understand what kind of information should correspond to each topic
  - 2.5 Given the instructor's explanations, the student will be able to
    - c) write reports and keep records which meet the requirements of codes and standards;.
    - d) implement procedure validations.
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#### METHODOLOGICAL STRATEGIES:

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

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#### EQUIPMENT AND RESOURCES:

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

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

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CONTENTS:

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- 3.1 Organization and administration of NDT
    - 3.1.1 Safety:
      - a) Implementation of industrial safety standards in facilities and equipment and in their operation
      - b) Hazards of using toxic and inflammable materials
      - c) Materials, accessories and equipment, for the protection of persons and facilities
    - 3.1.2 Organization
      - a) Organization structure of NDT Department or NDT organization
      - b) Equipment for work under way; Logistic provisions
      - c) Testing on production lines; Flow of materials; Work shifts
      - d) Maintenance of equipment and facilities
    - 3.1.3 Costs
      - a) Investments in equipment
      - b) Direct and indirect staff costs
      - c) Calculation and analysis of costs and profitability
    - 3.1.4 Equipment selection and facility design
    - 3.1.5 Operating procedures and record keeping
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SPECIFIC OBJECTIVES:

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

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

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EQUIPMENT AND RESOURCES:

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