SIMULA

Multimedia Training Courses on:
Non Destructive Testing, Metallurgy, Corrosion & …

UT	RT	MT	PT	VT	ET	PA - TOFD	ME-CO

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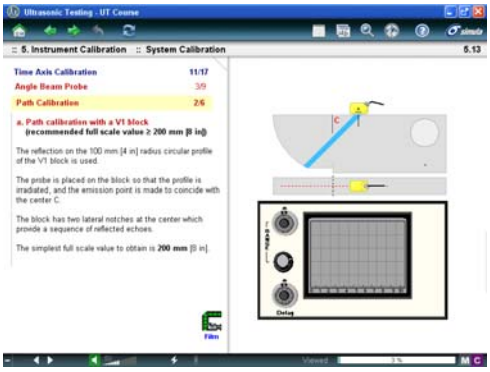
Update to March 2023

e-mail: simula@simula.it web-site: www.simula.it

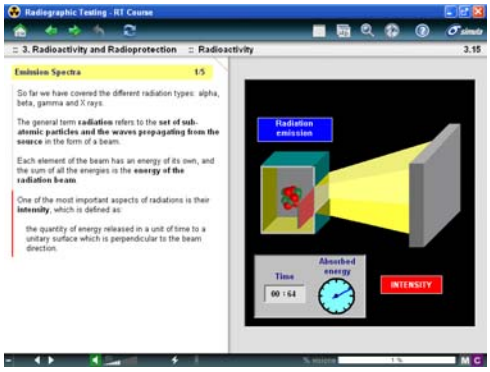
MULTIMEDIA TRAINING COURSES

Non Destructive Testing (NDT) – release 5.0

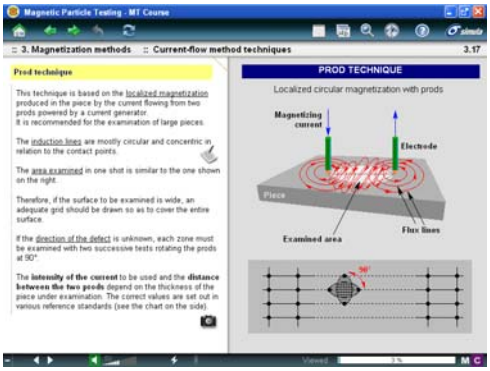
ULTRASONIC TESTING



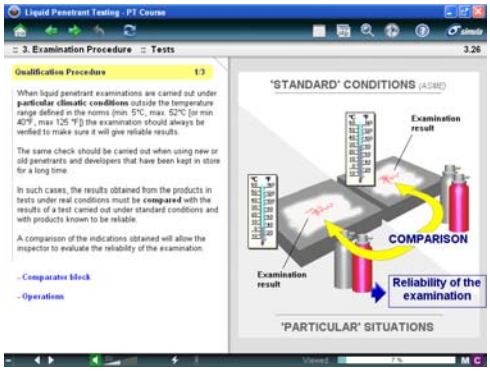
RADIOGRAPHIC TESTING



MAGNETIC PARTICLE TESTING



LIQUID PENETRANT TESTING



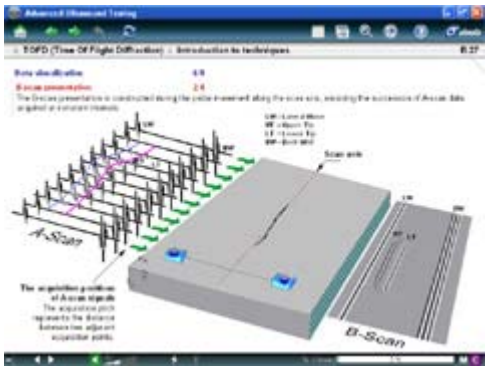
VISUAL TESTING

EDDY CURRENT TESTING

ADVANCED ULTRASONIC TESTING

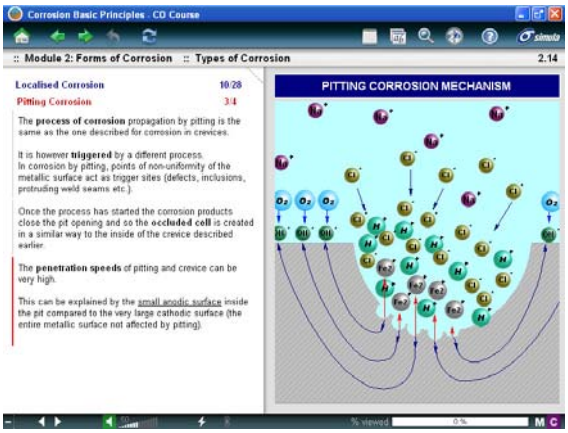
PHASED ARRAY

TOFD – Time of Flight Diffraction

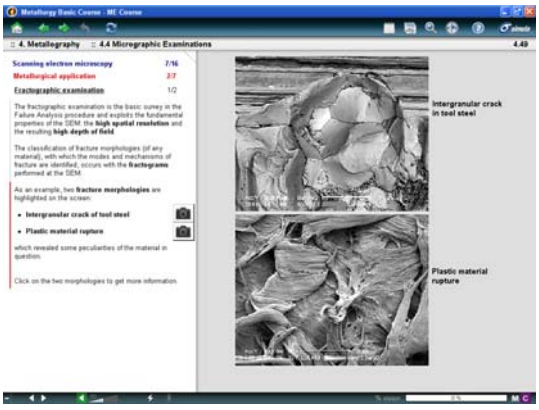


Corrosion and Metallurgy - release 5.0

CORROSION BASIC PRINCIPLES



METALLURGY BASIC COURSE



>> FEATURES

FEATURES

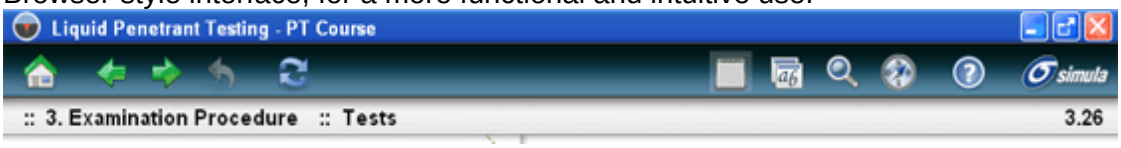
The courses have been designed with the idea of facilitating access to contents and their comprehension.

The attempt to achieve these objectives has led us to develop a set of tools for rapid navigation between sections of the course (index, map, route, search, bookmark) and to use different ways of presenting information (text, voice, video clips, self-assessment tests). The list of some this features is given below.

- Voice guide
- Interactive text
- Interactive animations
- Video clips
- Theory consolidation
- Intermediate self-assessment tests
- Final tests
- Glossary and Text search
- Display of path completed
- Bookmarking

Others features:

- Page size 1024 x 768 px.
- Browser-style interface, for a more functional and intuitive use.



- New tools, including the "User Notes" to record notes and pictures of personal experiences.
- Management of animation sequences, for a more simple and rapid comprehension.

- Integration of new topics.

AVAILABLE LANGUAGES

The NDT Training Courses are available in the following languages:

English (UT, RT, MT, PT, ET, VT, PA-TOFD, CO, ME)

Italian (UT, RT, MT, PT, ET, VT, PA-TOFD, CO, ME)

Spanish (UT, RT, MT, PT, VT, PA-TOFD)

French (RT, MT, PT)

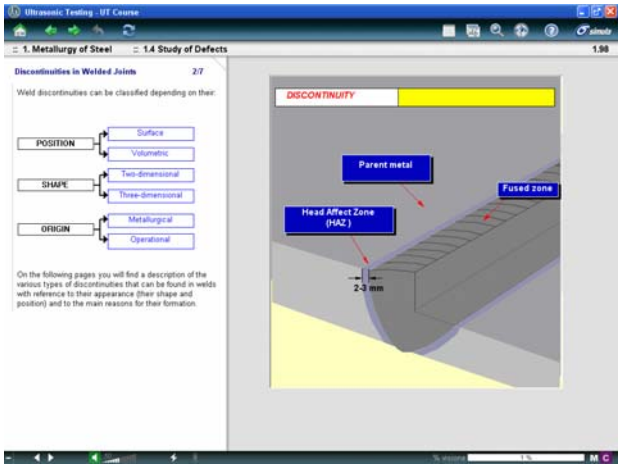
German (PT)

China (UT)

UT - ULTRASONIC TESTING

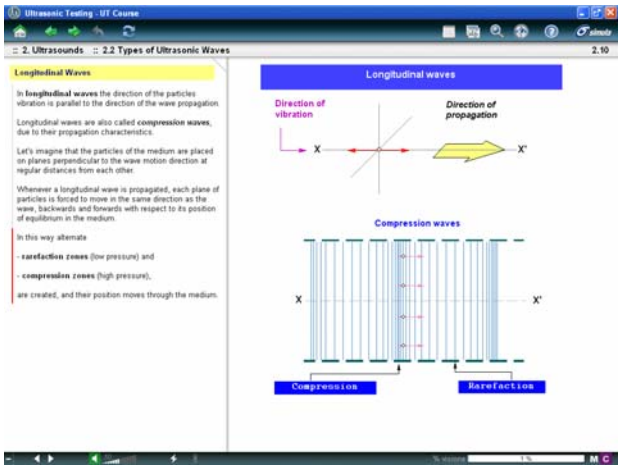
1. METALLURGY OF STEEL

- 1.1 Production of Carbon Steels
- 1.2 Heat Treatments
- 1.3 Mechanical Tests
- 1.4 Types of Fracture
- 1.5 Steel Products
- 1.6 Study of Defects
- Self-evaluation Tests



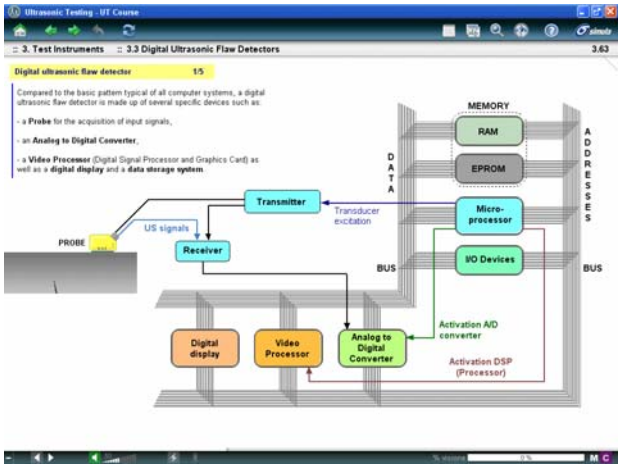
2. ULTRASOUNDS

- 2.1 Introduction
- 2.2 Types of Ultrasonic Waves
- 2.3 Parameters of Waves
- 2.4 Ultrasound Propagation
- Self-evaluation Tests



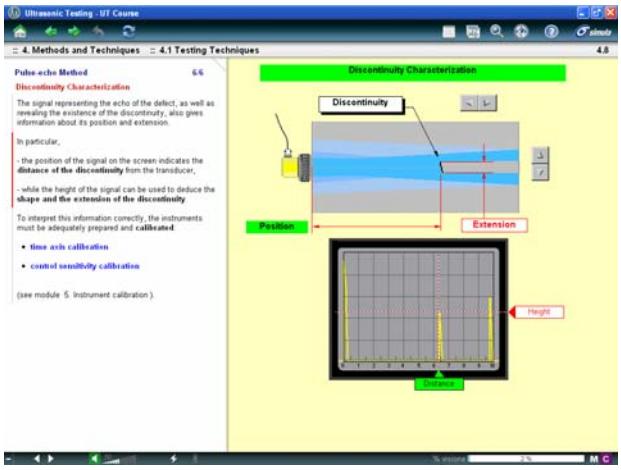
3. TEST INSTRUMENTS

- 3.1 Transducers
- 3.2 Ultrasound Equipment
- 3.3 Digital Ultrasound Equipment
- Self-evaluation Tests



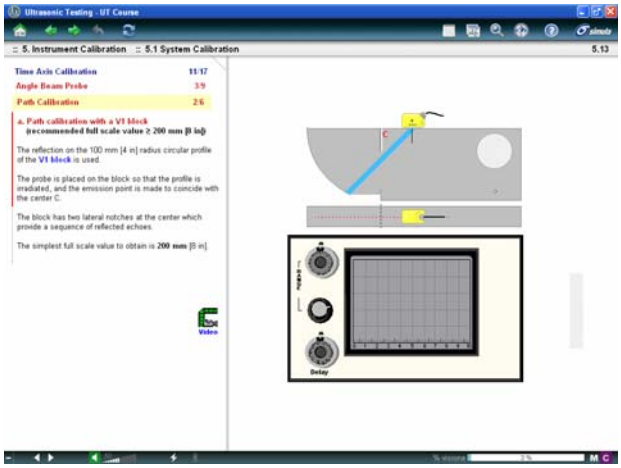
4. METHODS AND TECHNIQUES

- 4.1 Testing Methods
- 4.2 Testing Techniques
- Self-evaluation Tests



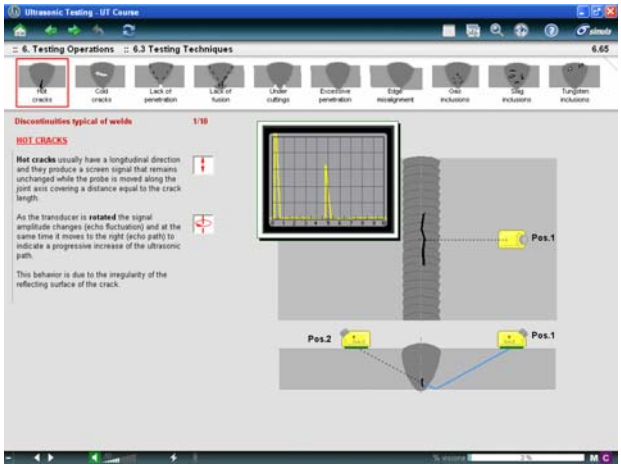
5. INSTRUMENT CALIBRATION

- 5.1 System Calibration
- 5.2 Periodic Calibration Check
- 5.3 Characterization of Probes
- 5.4 Reference Blocks
- Self-evaluation Tests



6. TESTING OPERATIONS

- 6.1 Piece Examination and Equipment Selection
- 6.2 Testing Procedure
- 6.3 Testing Techniques
- 6.4 Evaluation of Reflectors
- Self-evaluation Tests



FINAL TEST: **Over 700 final tests.**

NORMS: **Over 100 norm references**

Sim SCAN: **UT simulator**

ULTRASONIC TESTING: DETAILED INDEX

1. METALLURGY OF STEEL (>> UT)

1.1 Production of Carbon Steels
- · Manufacturing Process
- · Iron-Carbon Diagram
- · Addition of Elements
- · Classification of Steels
- · Designation of Steels
- · Stainless Steels

1.2 Heat Treatments
- · Full Annealing
- · Normalisation
- · Hardening
- · Tempering
- · Thermo-chemical Treatments: Cementation, Nitriding

1.3 Mechanical Tests
- · Tensile Test
- · Hardness Test
- · Resilience Test
- · Creep Test

1.4 Types of Fracture
- · Tough Fracture
- · Brittle Fractures
- · Fatigue Fractures

1.5 Steel Products
- · Classification of Products
- · Forged Pieces, Castings
- · Rolled Plates, Pipes
- · Welded Joints

1.6 Study of Defects
- · Discontinuities in Steel
- · Discontinuities in Forged Pieces
- · Discontinuities in Castings
- · Discontinuities in Rolled Plates
- · Discontinuities in Pipes
- · Discontinuities in Welded Joints

1.7 Self-evaluation Tests
- · Heat Treatments
- · Mechanical Tests
- · Types of Fractures
- · Production of Carbon Steels
- · Study of Defects

2. ULTRASOUNDS (>> UT)

2.1 Introduction
- · Generality of Waves
- · Wave Propagation
- · Wave Parameters
- · Wave Front
- · Ultrasonic Waves

2.2 Types of Ultrasonic Waves
- · Longitudinal Waves
- · Transverse Waves
- · Surface Waves
- · Lamb Waves

2.3 Parameters of Waves
- · Propagation Velocity
- · Frequency
- · Wavelength
- · Acoustic Impedance
- · Sound Pressure
- · Acoustic Intensity

2.4 Ultrasound Propagation
- · Huygens' Principle
- · Irradiation Field
- · Beam Attenuation
- · Laws of Reflection
  - Reflection on Thin Films
- · Laws of Refraction
  - Snell's Law
  - Critical Angles
  - Beams of Transverse Waves
- · Scattering
- · Diffraction

2.5 Self-evaluation Tests
- · Introduction to ultrasounds
- · Types of ultrasonic waves
- · Parameters of waves
- · Ultrasound propagation

3. TEST INSTRUMENTS (>> UT)

3.1 Transducers
- · Introduction to Transducers
- · Piezoelectric Transducers
- · Electrostrictive Transducers
- · Characteristics of Materials
- · Transducer Excitation
- · Types of Ultrasonic Transducers
  - Straight Beam Transducer
  - Angle Beam Transducer
  - Twin Crystal Contact Transducer
  - Wheel-type Transducers
  - Water-column Transducers
  - Immersion Transducers

3.2 Ultrasound Equipment
- · Introduction
- · Cathodic Ray Tube
- · Synchronizer
- · Transmitter
- · Sweep Generator
- · Delay Circuit
- · Receiver
- · Additional Equipment
- · Echo Presentation

3.3 Digital Ultrasonic flaw detectors
- · Analog and digital systems
- · Architecture of a digital system
- · Digital ultrasonic flaw detector
- · Components

3.4 Self-evaluation Tests
- · Transducers
- · Ultrasonic equipment
- · Digital Ultrasonic flaw detectors

- A/D Converter
- Digital Signal Processor
- Digital display

· Features
- Data storage
- Multi-channel operation mode
- Interface and control panel

· Digital flaw detector simulator
· Examples of digital flaw detector

4. METHODS AND TECHNIQUES (>> UT)

4.1 Testing Methods
· Pulse-echo Method
- Basic Signals
- Presence of a Discontinuity
- Typical Reflection Cases
- Discontinuity Characterization

· Resonance Method
- Resonance Frequency
- Depth of a Discontinuity

· Through-Transmission Method
- with Transmission
- with Reflection
- with Conduction

4.2 Testing Techniques
· Contact Technique
- Examination of the Surface
- Coupling Media

· Immersion Technique
- Straight Beam Testing
- Angled Beam Testing

· Comparison Between Techniques

4.3 Self-evaluation Tests
· Testing methods
· Testing techniques

5. INSTRUMENT CALIBRATION (>> UT)

5.1 System Calibration
· Time Axis Calibration
- Delay Calibration
- Longitudinal Beam Probe
- Angle Beam Probe

· Sensitivity Calibration
· Construction of a DAC curve
- Procedure
- Discontinuities Evaluation
- Distance-Amplitude Diagram
- Examples of the DAC curve

· DGS Diagrams
- Universal Diagrams
- Sizing Discontinuities
- Equivalent Diameter Calculation

5.2 Periodic Calibration Check
· Periodic Calibration Checks
· Horizontal Linearity Check
· Vertical Linearity Check
- Check the Echoes Heights Ratio
- Check the Surface-Amplitude Ratio

· Amplitude Control Linearity

5.3 Characterization of Ultrasonic Transducers

5.4 Reference Blocks
· Reference Blocks

Characterization of Longitudinal Probes
- · Ultrasonic Beam Profile
- · Alignment of the Beam

Characterization of Angle Probes
- · Emission Point
- · Emission Angle
- · Alignment of the Beam
- · Profile of the Ultrasonic Beam
  - Profile on the Vertical Plane
  - Profile on the Horizontal Plane
- · Amplification Reserve
- · Transverse Resolving Power

- · SDH Block, 1OW Block
- · Steel Block 25 x 150 x 250 mm
- · IIW V1 Block, IIW V2 Block
- · ASTM Blocks
- · Other Types of Blocks

5.5 Self-evaluation Tests
- · System calibration
- · Periodical calibration check
- · Characterization of ultrasonic transducers

6. TESTING OPERATIONS (>> UT)

6.1 Piece Examination and Equipment Selection
- · Examination of the Piece
- · Selection of the Equipment
  - Ultrasound Equipment
  - Probe
  - Coupling Medium

6.2 Testing procedure
- · Surface Preparation
- · Calibration of the Equipment
- · Non-welded Components
  - Tests with Longitudinal Probes
  - Tests with Angle Probes
- · Tests on Welds
- · Norms and Standards

6.3 Testing Techniques
- · Tests on Rolled Plates
- · Tests on Forged Pieces
  - Tests with Longitudinal Beam Probes
  - Tests with Angle Beam Probes
- · Tests on Castings
- · Tests on Seamless Pipes
  - Longitudinal Discontinuities
  - Transverse Discontinuities
- · Tests on Welded Joints
  - Longitudinal Discontinuities in Butt Joints
  - Transverse Discontinuities in Butt Joints
  - Nature of the Discontinuity
  - Discontinuities Typical of Welds
  - Detection of Discontinuities in Tee Joints

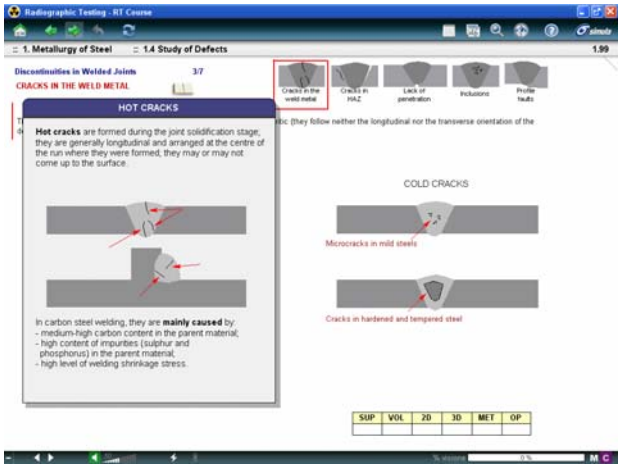
6.4 Evaluation of reflectors
- · False Indications
- · Locate the Defect
  - Longitudinal Beam Scanning
  - Angled Beam Scanning
- · Sizing the Defects
  - System for Measuring Reflected Intensity
  - Reflector Outline Definition System

6.5 Self-evaluation Tests
- · Testing procedure
- · Testing techniques
- · Evaluation of reflectors

RT - RADIOGRAPHIC TESTING

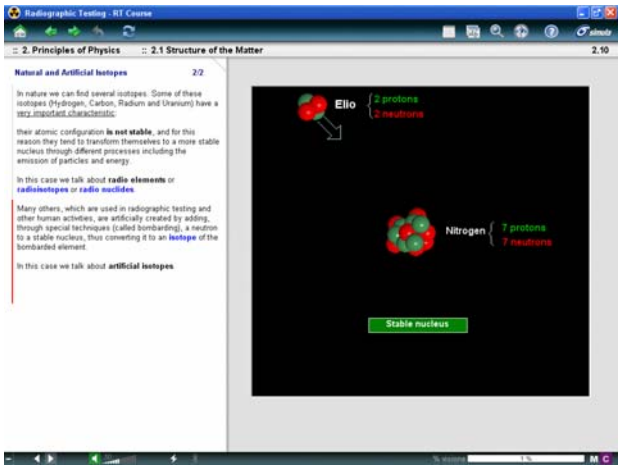
1. METALLURGY OF STEEL

- 1.1 Production of Carbon Steels
- 1.2 Heat Treatments
- 1.3 Mechanical Tests
- 1.4 Types of Fracture
- 1.5 Steel Products
- 1.6 Study of Defects
- Self-evaluation Tests



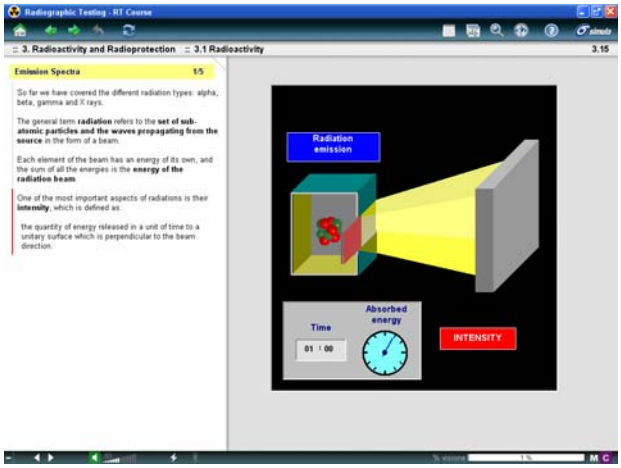
2. PRINCIPLES OF PHYSICS

- 2.1 Structure of the Matter
- 2.2 Electromagnetic Waves
- 2.3 Electricity
- Self Evaluation Test



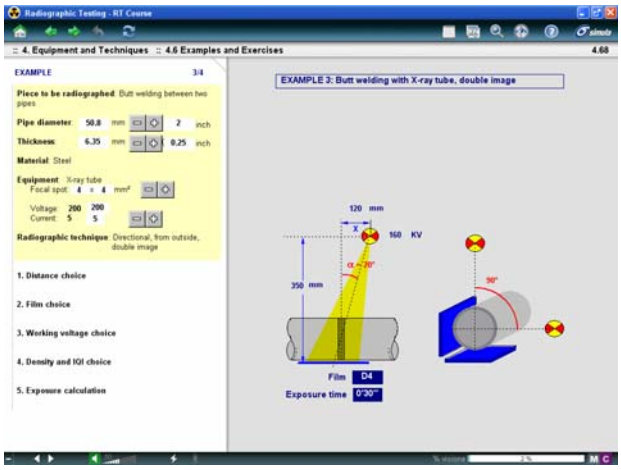
3. RADIOACTIVITY AND RADIOPROTECTION

- 3.1 Radioactivity
- 3.2 Radioprotection
- Self Evaluation Test



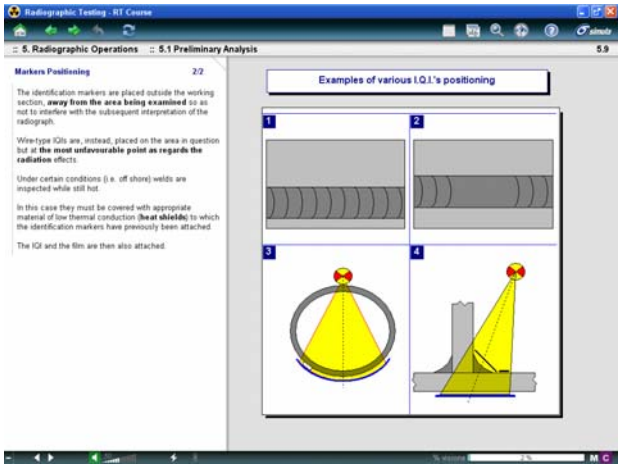
4. EQUIPMENT AND TECHNIQUES

- 4.1 Radiation Generators
- 4.2 Films
- 4.3 Image Quality
- 4.4 Exposure Factors
- 4.5 Radiographic Techniques
- 4.6 Examples and Exercises
- Self Evaluation Test



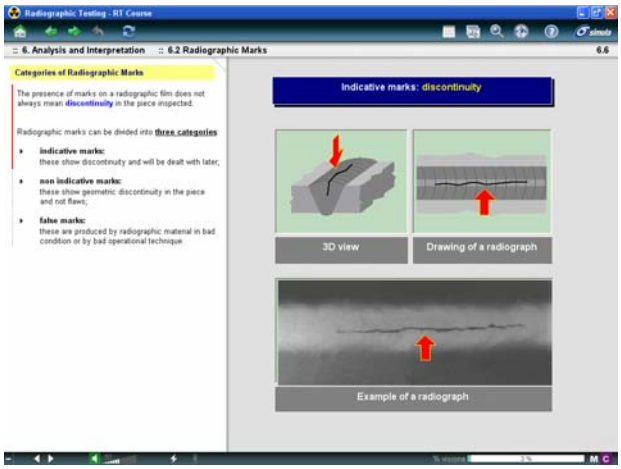
5. RADIOGRAPHIC OPERATIONS

- 5.1 Preliminary Analysis
- 5.2 Radiographic Inspection
- 5.3 Developing
- Self Evaluation Test



6. ANALYSIS AND INTERPRETATION

- 6.1 Analysis Instruments
- 6.2 Radiographic Marks
- 6.3 Radiograph Reading
- Self Evaluation Test



VIDEOTHEQUE

FINAL TEST: Over 600 final tests.

NORMS: Over 100 norm references

RADIOGRAPHIC TESTING: DETAILED INDEX

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- · Welded Joints

1.6 Study of Defects
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- · Discontinuities in Forged Pieces
- · Discontinuities in Castings
- · Discontinuities in Rolled Plates
- · Discontinuities in Pipes
- · Discontinuities in Welded Joints

1.7 Self-evaluation Tests
- · Heat Treatments
- · Mechanical Tests
- · Types of Fractures
- · Production of Carbon Steels
- · Study of Defects

2. PRINCIPLES OF PHYSICS (>> RT)

2.1 Structure of the Matter
- · Structure of the Atom
- · Natural and Artificial Isotopes
- · Structure of Metals

2.2 Electromagnetic Waves
- · Wave Concept
- · Wave Parameters
- · Electromagnetic Waves

2.3 Electricity
- · Electrical Charge
- · Electrical Field
- · Potential Difference
- · Electrical Current
- · Resistance
- · Joule Effect
- · Transformer

2.4 Self Evaluation Test
- · Structure of the matter
- · Electromagnetic waves
- · Electricity

3. RADIOACTIVITY AND RADIOPROTECTION (>> RT)

3.1 Radioactivity
- · Radiations
- · Decay
- · X-rays
- · Emission Spectra
- · Penetration Power
- · Ionization
- · Absorption
- · Unit of Measure

3.2 Radioprotection
- · Meaning of Dose
- · Biological Effects of Radiation
- · Dose Limits
- · Radiation Protection
- · Radiation Measurement

3.3 Self Evaluation Test
- · Radioactivity
- · Radioprotection

4. EQUIPMENT AND TECHNIQUES (>> RT)

4.1 Radiation Generators
- · X-ray Equipment
- · Gamma Ray Equipment
- · Crawler-Fitted X and Gamma Sources

4.2 Films
- · Film
- · Sensitometric Curves
- · Types of Films
- · Film Choice
- · Intensifying Screens
- · Comparison Between X and Gamma Rays

4.3 Image Quality
- · Sensitivity
- · Image Quality Factors
- · Image Quality Indicators
- · Synthesis of Image Quality Parameters

4.4 Exposure Factors
- · Exposure Diagrams
- · Correction Factors
- · Equivalent Radiographs
- · Slide Rule for Gamma-Rays

4.5 Radiographic Techniques
- · Weld Testing
- · Casting and Forging Examination

4.6 Examples and Exercises
- · EXAMPLES
- · EXERCISES

4.7 Self Evaluation Test
- · Radiation generators
- · Films
- · Image quality
- · Exposure factors
- · Radiographic techniques

5. RADIOGRAPHIC OPERATIONS (>> RT)

5.1 Preliminary Analysis
- · Study of the Test Piece
- · Films Preparation
- · Markers Positioning
- · Film Positioning
- · Source Positioning
- · Shield Positioning
- · Cordon off the Controlled Area
- · Filmed Synthesis of Preliminary Analysis

5.2 Radiographic Inspection
- · Setting of the X-ray Parameters
- · Preparation of a Gamma-ray Equipment
- · Operations to Carry Out a Radiograph
- · Safety During the Exposure
- · Safety After the Exposure

5.3 Developing
- · Film Preparation
- · Developing Process
- · Equipment for Manual Developing
- · Equipment for Automatic Developing
- · Filmed Synthesis of the Developing

5.4 Self Evaluation Test
- · Radiographic inspection
- · Developing

6. ANALYSIS AND INTERPRETATION (>> RT)

6.1 Analysis Instruments
- · Negatoscopes
- · Densitometers

6.2 Radiographic Marks
- · Categories of Radiographic Marks
- · False Marks
- · Imperfect Radiographs
- · Indicative Marks

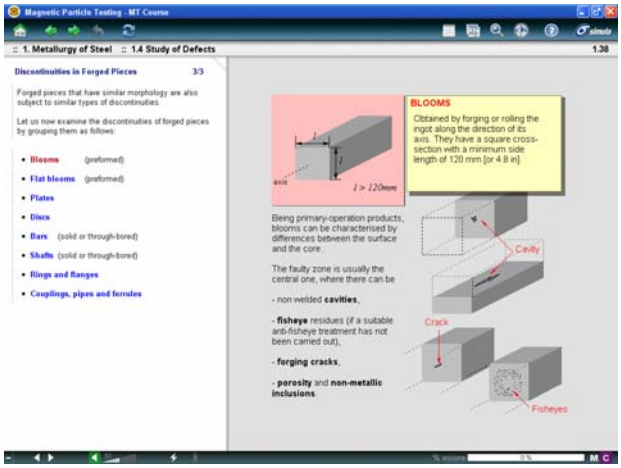
6.3 Radiograph Reading
- · Conditions of the Radiograph Reading
- · General Interpretation Aspects
- · Visibility of the Defects
- · Acceptability Standard
- · Radiograph Archive
- · Reading Exercise

6.4 Self Evaluation Test
- · Analysis instruments
- · Radiographic marks
- · Radiograph reading

MT - MAGNETIC PARTICLE TESTING

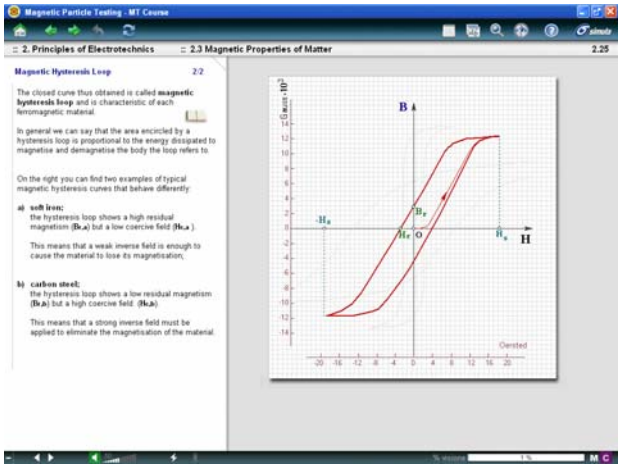
1. METALLURGY OF STEEL

- 1.1 Steel
- 1.2 Heat Treatments
- 1.3 Production of Carbon Steels
- 1.4 Study of Defects
- Self-evaluation test



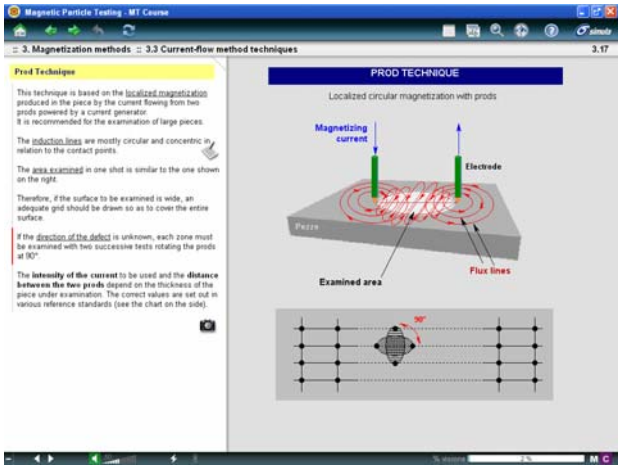
2. ELECTROTECHNICS PRINCIPLES

- 2.1 Natural magnetism
- 2.2 Electricity and magnetism
- 2.3 Magnetic properties of matter
- 2.4 Electric current
- 2.5 Standard Units
- Self-evaluation test



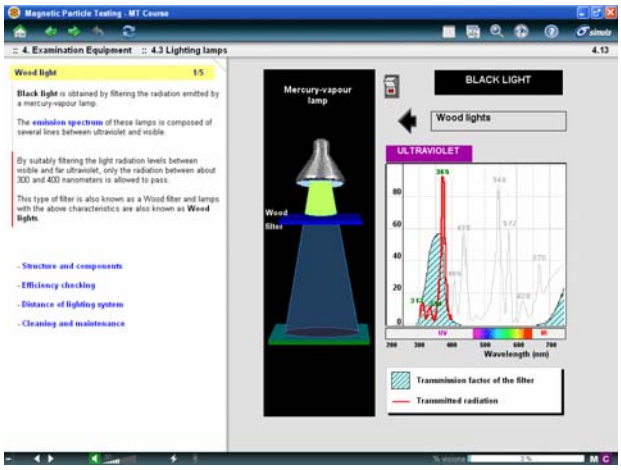
3. MAGNETIZATION METHODS

- 3.1 Examination principle
- 3.2 Criteria for the examination
- 3.3 Current-flow method techniques
- 3.4 Magnetic-field method techniques
- 3.5 Magnetizing currents
- Self-evaluation test



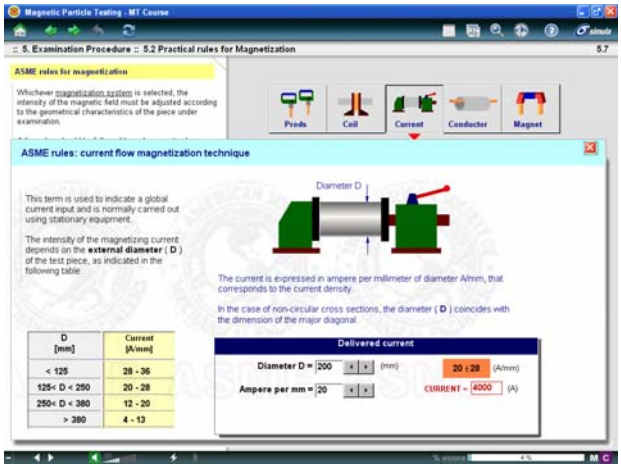
4. EXAMINATION EQUIPMENT

- 4.1 Magnetic particles
- 4.2 Characteristic of the particles
- 4.3 Lighting lamps
- 4.4 Magnetization Equipment
- Self-evaluation test



5. EXAMINATION PROCEDURE AND RESULTS EVALUATION

- 5.1 Preliminary activities
- 5.2 Magnetization rules
- 5.3 Magnetic field checking
- 5.4 Sequence of operations
- 5.5 Test results evaluation
- Self-evaluation test



VIDEOTHEQUE

FINAL TEST: Over 600 final tests.

NORMS: Over 50 norm references

MAGNETIC PARTICLE TESTING: DETAILED INDEX

1. METALLURGY OF STEEL (>> MT)

1.1 Steel
- · Introduction
- · Components
- · Solidification
- · Iron-Carbon Diagram

1.2 Heat Treatments
- · Introduction
- · Annealing
- · Normalization

1.3 Production of Carbon Steels
- · Manufacturing Process
- · Classification of Products
  - - Forged pieces
  - - Castings
  - - Rolled plates
  - - Pipes
  - - Welded joints

1.4 Study of Defects
- · Discontinuities in steel
- · Discontinuities in forged pieces
- · Discontinuities in castings
- · Discontinuities in rolled plates
- · Discontinuities in pipes
- · Discontinuities in welded joints

1.5 Self-evaluation test
- · Steel
- · Heat Treatments
- · Production of Carbon Steels
- · Study of Defects

2. ELECTROTECHNICS PRINCIPLES (>> MT)

2.1 Natural magnetism
- · Magnets
- · Magnetic Field

2.2 Electricity and magnetism
- · Introduction
- · Rectilinear conductor
- · Loop
- · Coil
- · Solenoid
- · Toroidal coil
- · Magnetomotive force

2.3 Magnetic properties of matter
- · Ferromagnetism
- · Magnetic Induction
- · Magnetic hysteresis loop
- · Magnetic flux

2.4 Electric current
- · Electric current definition
- · Kinds of current
- · Alternating current parameters
- · Measuring instruments

Standard Units

2.5 Self-evaluation test
- · Electricity and magnetism
- · Magnetic properties of matter
- · Electric current

3. MAGNETIZATION METHODS (>> MT)

3.1 Examination principle
- · Magnetic particle examination
- · Advantages and limitations

3.2 Criteria for the examination
- · Examination methods
- · Magnetization methods
- · Types of magnetization

3.3 Current-flow method techniques
- · Current-flow methods
- · Electrodes at either end of the piece
- · Prod technique

3.4 Magnetic-field method techniques
- · Magnetic-field method techniques
- · Central conductor
- · Yoke technique
- · Coil
- · Through-cable technique

3.5 Magnetizing currents
- · Magnetizing currents
- · Direct current
- · Alternating current
- · Rectified current
- · Current values

3.6 Self-evaluation test
- · Examination principle
- · Method techniques
- · Magnetizing currents

4. EXAMINATION EQUIPMENT (>> MT)

4.1 Magnetic particles
- · Types of examination medium
- · Dry examination medium
- · Wet examination medium
- · Examination medium with contrast paint

4.2 Characteristic of the particles
- · Types of powders
- · Efficiency of powders
- · Checking the efficiency of powders

4.3 Lighting lamps
- · Light classification
- · Wood light
  - - Structure and components
  - - Efficiency checking
  - - Distance of lighting system
  - - Cleaning and maintenance

4.4 Magnetization Equipment
- · Equipment classification
- · Stationary magnetic-particle inspection unit
- · Generator for prod examination
- · Portable magnets
- · Portable electromagnets
- · Efficiency of the equipment

4.5 Self-evaluation test
- · Magnetic particles
- · Lighting lamps
- · Magnetization equipment

5. EXAMINATION PROCEDURE AND RESULTS EVALUATION (>> MT)

5.1 Preliminary activities
- · Test piece inspection
- · Standard References

5.2 Magnetization rules
- · ASME rules

5.3 Magnetic field checking
- · Optimum induction level
- · Instruments for the checking of magnetizing field
  - - ASME probe
  - - Berthold's probe
  - - Reference block
  - - Gauss meter

5.4 Sequence of operations
- · Sequence of operations
- · Step 1: Surface preparation
- · Step 2: Checking for residual fields
- · Step 3: Magnetization and spraying
- · Step 4: Visual inspection
- · Step 5: Demagnetization
- · Step 6: Protective treatment

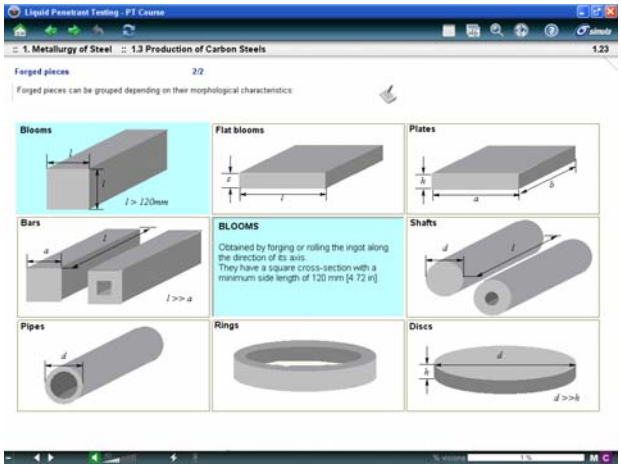
5.5 Test results evaluation
- · Detecting a discontinuity
- · Types of indications
- · Types of discontinuities

5.6 Self-evaluation test
- · Practical rules for magnetization
- · Checking the magnetizing field
- · Sequence of operations
- · Evaluation of test results

PT - LIQUID PENETRANT TESTING

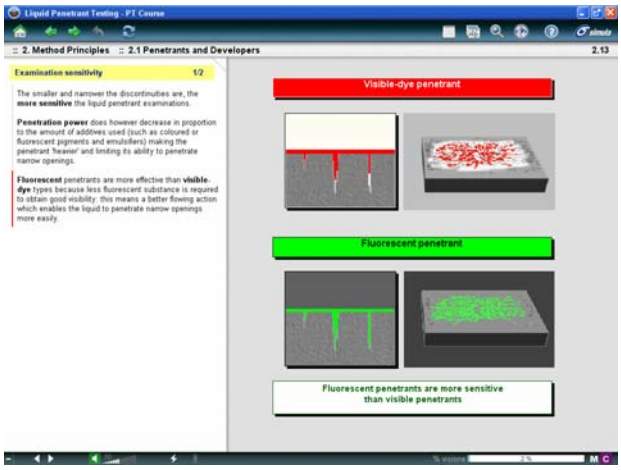
1. METALLURGY OF STEEL

- 1.1 Steel
- 1.2 Heat Treatments
- 1.3 Production of Carbon Steels
- 1.4 Study of Defects
- Self-evaluation test



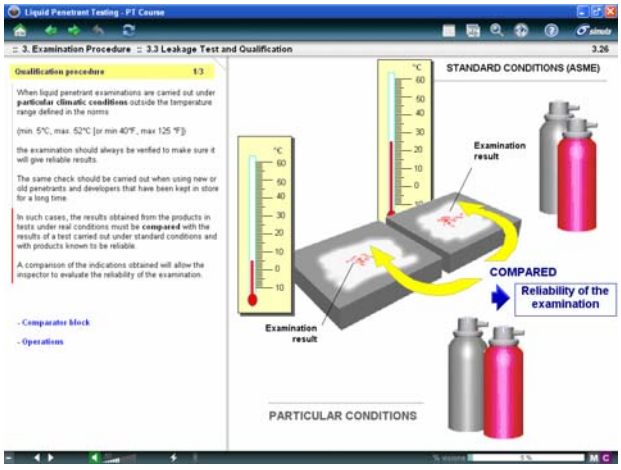
2. METHOD PRINCIPLES

- 2.1 Penetrants and Developers
- 2.2 Light Sources
- Self-Evaluation Test



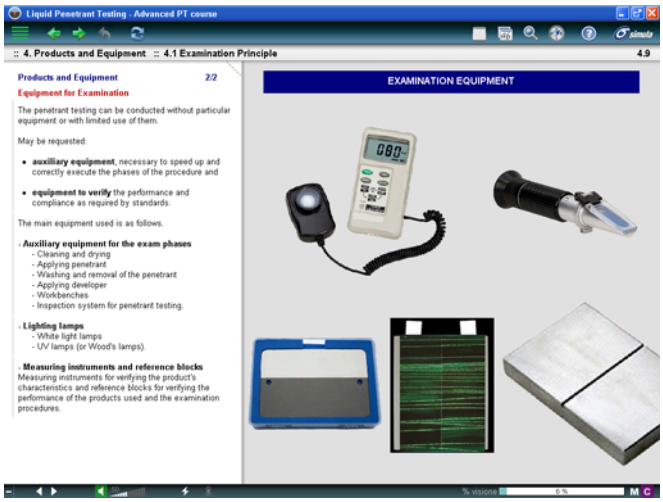
3. EXAMINATION PROCEDURE

- 3.1 Preliminary Activities
- 3.2 Examination Operations
- 3.3 Tests
- Self-Evaluation Test



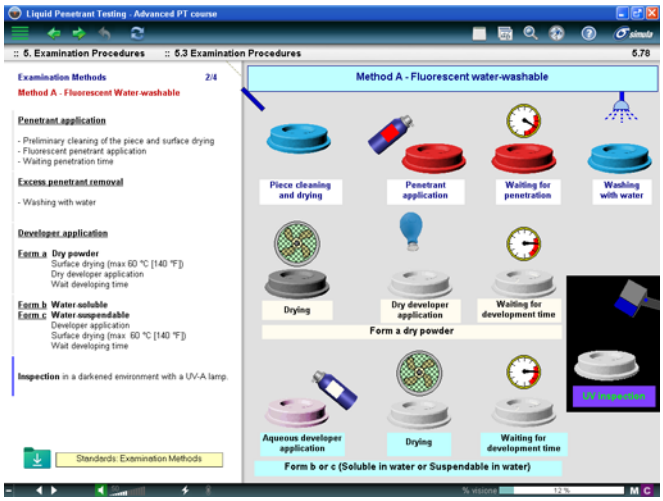
4. PRODUCT AND EQUIPMENT

- 4.1 Examination Principle
- 4.2 Liquids Penetrant
- 4.3 Developers
- 4.4 Solvents and Emulsifiers
- 4.5 Examination Equipment
- 4.6 Performance and Features
- Self-Evaluation Test



5. EXAMINATION PROCEDURE

- 5.1 Preliminary Activities
- 5.2 Examination Phases
- 5.3 Examination Procedures
- 5.4 Detectable Discontinuities
- 5.5 Qualification and Leak Test
- Self-Evaluation Test



VIDEOTHEQUE

FINAL TEST: Over 500 final tests.

NORMS: Over 40 norm references

LIQUID PENETRANT TESTING: DETAILED CONTENTS

1. METALLURGY OF STEEL (>> PT)

1.1 Steel
- · Introduction
- · Components
- · Solidification
- · Iron-Carbon Diagram

1.2 Heat Treatments
- · Introduction
- · Annealing
- · Normalization

1.3 Production of Carbon Steels
- · Manufacturing Process
- · Classification of Products
  - - Forged pieces
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  - - Rolled plates
  - - Pipes
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- · Discontinuities in steel
- · Discontinuities in forged pieces
- · Discontinuities in castings
- · Discontinuities in rolled plates
- · Discontinuities in pipes
- · Discontinuities in welded joints

1.5 Self-evaluation test
- · Steel
- · Heat Treatments
- · Production of Carbon Steels
- · Study of Defects

2. METHOD PRINCIPLES (>> PT)

2.1 Penetrants and Developers
- · Examination Principle
- · Penetrants Classification
- · Chemical Characteristics
- · Physical Properties
- · Other Properties
- · Examination Sensitivity
- · Developers
- · Developers Classification
- · Synthesis of the Characteristics

2.2 Light Sources
- · Classification
- · Black Light Lamp
  - - Structure and components
  - - Efficiency Verification
  - - Distance of lighting system
  - - Cleaning and Maintenance

2.3 Self-Evaluation Test
- · Penetrants and developers
- · Light sources

3. EXAMINATION PROCEDURE (>> PT)

3.1 Preliminary Activities
- · Test piece inspection
- · Standards References
- · Selection of method and type of liquid

3.2 Examination Operations
- · Introduction
- · STEP 1: Surface Cleaning
- · STEP 2: Penetrant Application
- · STEP 3: Dwell Time
- · STEP 4: Penetrant Removal
- · STEP 5: Developer Application
- · STEP 6: Evaluation of the Indications
- · Synthesis of Operation

3.3 Tests
- · Leakage Test
- · Procedure Qualification
  - Comparator block
  - Operations

3.4 Self-Evaluation Test
- · Examination operations
- · Tests

4. PRODUCT AND EQUIPMENT (>> PT)

4.1 Examination Principle

- · Examination Principle
- · Detectable Defects
- · Types of Materials and Applications
- · Advantages of Method
- · Limitations of Method
- · Products for Examination
- · Equipment for Examination

4.2 Liquids Penetrant

· Introduction

· Types of Penetrants
- Fluorescent Penetrants
- Color Contrast Penetrants
- Combined Penetrants
- Penetrants for Special Applications

· Penetrants Classification
- Water Washable Penetrants
- Solvent Removable Penetrants
- Post-Emulsification Penetrants
- Examination Methods
- Examination Sensitivity

· Characteristics and Properties
- Characteristics of Penetrants
- Physical and Chemical Properties
- Other Properties

4.3 Developers

· Introduction

· Developers Classification

· Developers Forms
- Dry Developers (Form a)

4.4 Solvents and Emulsifiers
- · Introduction

· Solvents
- Types of Solvents

- Wet Developers (Forms b, c, d, e)
- Aqueous Developers (Form b)
- Aqueous Developers (Form c)
- Non-aqueous Developer (Form d, e)
- Other Forms of Developers (Form f)

· Developer Application
· Developer Composition
· Developer Characteristics
· Advantages / Disadvantages of Developers
· Synthesis of the Characteristics

- Use of Solvents

· Emulsifiers
- Types of Emulsifiers
- Lipophilic Emulsifier (oil-based)
- Hydrophilic Emulsifier (water-based)
- Emulsifiers Comparison

· Emulsifier Application
- Preparation
- Application Mode

· Emulsification Time
· Washing and Complete Removal Control
· Emulsifiers Characteristics

4.5 Examination Equipment

· Light Sources
- Black Light Lamp
- UV Lamp Types
- Mercury Vapor UV Lamps
- LED UV Lamps
- Cleaning and Maintenance

· Measuring Instruments
- Photometer
- UV-A Radiometer
- Refractometer
- Photo Fluorimeter

· Reference Blocks
- EN ISO Blocks (Type 1 and 2)
- TAM Panel
- Comparator Block
- Comparator Rules

· Penetrant Test Kit

· Inspection Systems
- Types of plant
- Stations of a plant
- Plant configuration

4.6 Performance and Features

· Performance Check
- Removability check
- Sensitivity evaluation
- Contamination and degradation check
- Color Dye and fluorescence check

· Features Check
- Penetrant features check
- Developer features check

Self-Evaluation Test

· Examination Principle
· Penetrants and Developers
· Solvents and Emulsifiers
· Examination Equipment
· Performance and Features Check

5. EXAMINATION PROCEDURE (>> PT)

5.1 Preliminary Activities

· Test Piece Inspection
· Choice Method and Penetrant
· Standards References
· Written Procedure

5.2 Examination Phases

· Introduction
· STEP 1: Surface Cleaning
· STEP 2: Penetrant Application
· STEP 3: Penetration (Dwell) Time
· STEP 4: Removing Excess Penetrant
· STEP 5: Developer Application
· STEP 6: Inspection
· Post Cleaning
· Operations Synthesis

5.3 Examination Procedures

· **Examination procedures**
- Examination with color contrast penetrants
- Examination with fluorescent penetrants
- Examination with water-washable penetrants
- Examination with solvent removable penetrants
- Examination with post-emulsifiable penetrants

· Examination Methods
Method A - Water Washable Fluorescents
Method B and D - Post-emulsifiable Fluorescents
Method C - Solvent Removable
· **Safety Standards**

5.4 Detectable Discontinuities

· Detectable Discontinuities
· Main Discontinuities

5.5 Qualification and Leak Test

· Qualification Procedure
- Comparator Block
- Operations
· Leak Test
· Examination at Nonstandard Temperatures
- Examination at Low Temperatures
- Examination at High Temperatures

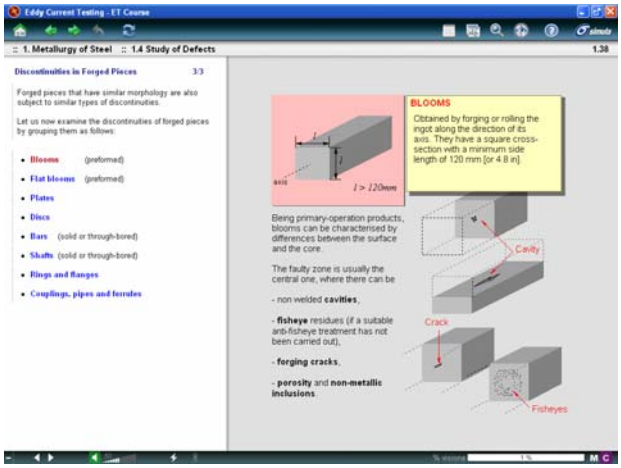
5.6 Self-Evaluation Test

· Preliminary Activities
· Examination Operations
· Examination Procedures
· Detectable Discontinuities
· Qualification and Leak Test

ET - EDDY CURRENT TESTING

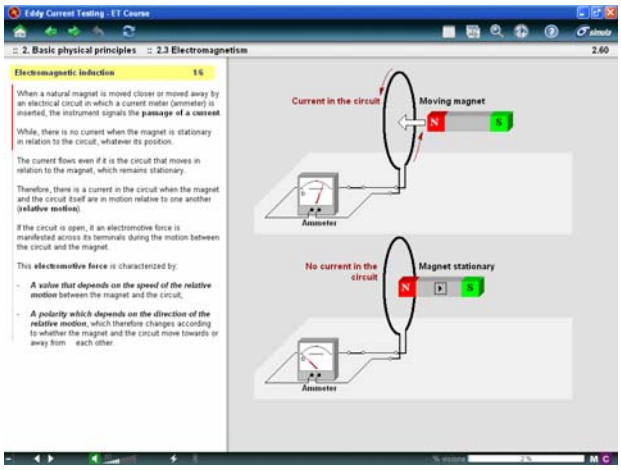
1. METALLURGY OF STEEL

- 1.1 Steel
- 1.2 Heat Treatments
- 1.3 Production of Carbon Steels
- 1.4 Study of Defects
- Self-evaluation Test



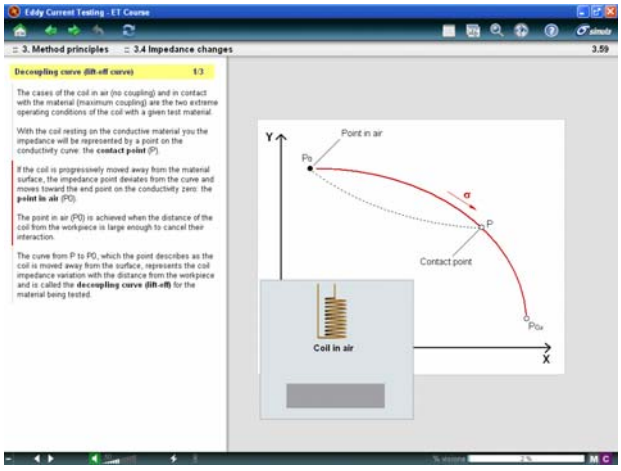
2. BASIC PHYSICAL PRINCIPLES

- 2.1 Electricity
- 2.2 Magnetism
- 2.3 Electromagnetism
- 2.4 Measurement units
- Self-evaluation Test



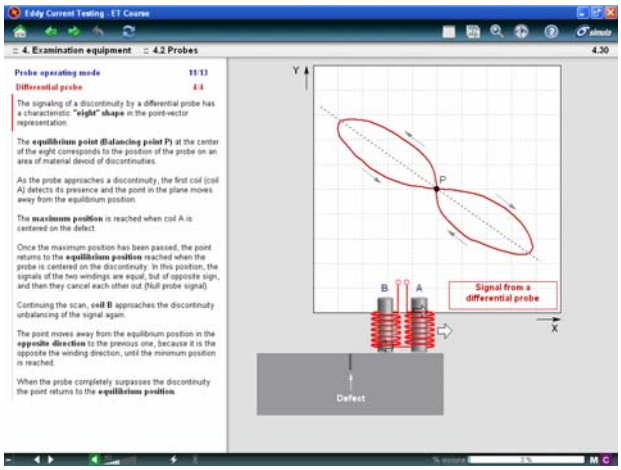
3. METHOD PRINCIPLES

- 3.1 Eddy current method
- 3.2 Eddy current properties
- 3.3 Factors affecting the eddy current
- 3.4 Impedance changes
- 3.5 Impedance diagrams
- Self-evaluation Test



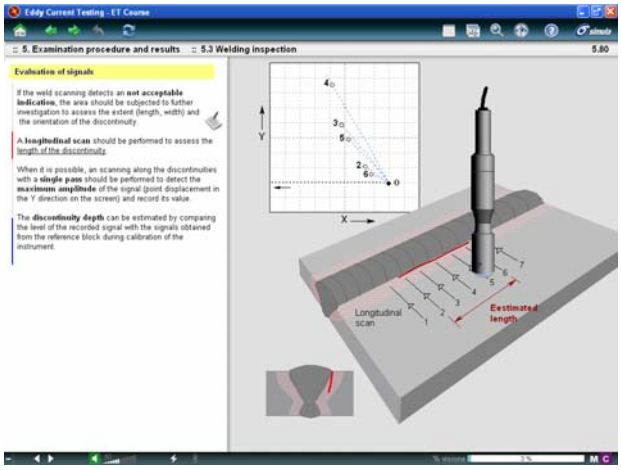
4. EXAMINATION EQUIPMENT

- 4.1 Examination system
- 4.2 Probes
- 4.3 Instruments
- 4.4 Reference standards
- Self-evaluation Test



5. EXAMINATION PROCEDURE AND RESULTS

- 5.1 General examination
- 5.2 Surface inspections
- 5.3 Welding inspection
- 5.4 Tube inspections with an internal probe
- 5.5 Tube and bar inspections with an external probe
- 5.6 Measuring thickness
- 5.7 Measuring conductivity
- Self-evaluation Test



FINAL TEST

NORMS

EDDY CURRENTE TESTING: DETAILED CONTENTS

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- · Annealing
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- · Classification of Products
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  - - Castings
  - - Rolled Plates
  - - Pipes
  - - Welded Joints

1.4 Study of Defects
- · Discontinuities in Steel
- · Discontinuities in Forged Pieces
- · Discontinuities in Castings
- · Discontinuities in Rolled Plates
- · Discontinuities in Pipes
- · Discontinuities in Welded Joints

1.5 Self-evaluation Test
- · Steel
- · Heat Treatments
- · Production of Carbon Steels
- · Study of Defects

2. BASIC PHYSICAL PRINCIPLES (>> ET)

2.1 Electricity
1. Electric charge
2. Electric field
   - - Work of the electric field
   - - Electric potential energy
   - - Electric potential
   - - Potential difference
3. Electric current
   - - Intensity and direction of the current
   - - Electric current density
4. Electromotive force
5. Electrical resistance
   - - Resistivity and conductivity
   - - Resistivity and temperature
6. Direct current
   - - Ohm's Law
7. Alternating current
   - - Alternating current parameters
   - - Skin effect
   - - Vector representation
8. Electric power
9. Thermal effect of the current (Joule effect)

2.2 Magnetism
1. Magnets
2. Magnetic Field
3. Ferromagnetism
4. Magnetic Induction
   - - Magnetic permeability
   - - Normal magnetization curve
5. Magnetic Hysteresis Loop
6. Magnetic Flux
   - - Conservation of magnetic flux

2.3 Electromagnetism

1. Magnetic field produced by current
   - Rectilinear Conductor
   - Circular loop
   - Coil
   - Solenoid
   - Toroidal coil

2. Magnetic circuits
   - Hopkinson's law
   - Analogies with electrical circuits

3. Electromagnetic induction
   - Faraday's law of induction
   - Eddy Current or Induced current
   - Lenz's law
   - AC voltage generator (Alternator)

4. Self-induction
   - Self-induced electromotive force
   - Coefficient of self-induction (or inductance)
   - Inductive circuit

5. Mutual induction
   - Coefficient of mutual inductance
   - Coupling coefficient

6. Alternating current circuits
   - Purely resistive circuit (Ohmic circuit)
   - Purely inductive circuit(L circuit)
   - Resistor - Inductor circuit (RL circuit)

2.4 Measurement units

1. Electromagnetic quantities

2. Base Units

3. Derived units

3. METHOD PRINCIPLES (>> ET)

3.1 Eddy current method

1. General description
2. Typical applications
3. Advantages
4. Limitations

3.2 Eddy current properties

1. Introduction
2. Eddy currents paths
   - Surface coil (surface probe)
   - Encircling coil
   - Inside diameter coil
3. Penetration depth
   - Standard penetration depth
   - Calculation of standard depth
   - Eddy currents densities
   - Frequency dependence
   - Penetration curves
   - Effective penetration depth
4. Phase shift with depth
   - Calculating phase angle
5. Calculation expressions

3.3 Factors affecting the eddy current

1. Introduction
2. Material properties
   - Conductivity of the material
   - IACS system
   - Magnetic permeability
3. Part geometry
   - Thickness of the workpiece
   - Surface shape
4. Presence of discontinuities
   - Shape and orientation of discontinuities
   - Depth of discontinuity
5. Eddy current coupling
   - Lift-off
   - Fill factor
6. Supply frequency of the coil
7. Edge effect

3.4 Impedance changes

1. Introduction
2. Coil impedance
3. Impedance plane
4. Conductivity curve
5. Decoupling curve (lift-off curve)
6. Frequency effects
7. Material thickness effect
8. Non-conductive coating
9. Conductive coating
10. Discontinuity signals
11. Effect of magnetic permeability

3.5 Impedance diagrams

1. Normalized impedance
2. Normalized frequency
3. Diagram: coil on surface
   - Influence of normalized parameters
4. Diagram: external coil with bar
   - Influence of normalized parameters
5. Diagram: external coil with tube
   - Influence of normalized parameters

4. EXAMINATION EQUIPMENT (>> ET)

4.1 Examination system

1. Parts of the system
2. Eddy current probe
3. Eddy current instrument

4.2 Probes

1. Probe classification
2. Coils configuration
   - Encircling probe
   - Internal probe
   - Surface probe
   - Probes with ferrite core
   - Shielded probes
3. Probe operating mode
   - Single coil probe
   - Reflection probe
   - Absolute probe
   - Differential probe
   - Transmission probe
   - Induction bridge
4. Structure of the coil
   - Calculation inductance

4.3 Instruments

1. Instruments of exam
2. Oscillator
3. Measuring circuit
   - Bridge measuring circuit
   - Maxwell-Wien bridge
   - Measuring with absolute probes
   - Measuring with compensated probes
   - Measuring with differential probes
   - Measuring with reflection probes
4. Phase analysis
5. Phase rotation
6. Band-pass filters
   - Frequency response
   - Types of filters
   - Effect of the filters on the signal
7. Display device
   - Digital displays
   - Settings
8. Eddy current instruments
   - Meters instruments
   - Portable instruments
   - Multi-frequency instrument

4.4 Reference standards

1. Generality
2. Conductivity samples
3. Calibration reference standards
   - Samples with natural discontinuities
   - Samples with artificial discontinuities
4. Lift-off samples

5. EXAMINATION PROCEDURE AND RESULTS (>> ET)

5.1 General examination

1. Introduction
2. Sensitivity to defects
   - Lift-off
   - Penetration depth
   - Coil parameters
3. Signal phase discrimination
4. Frequency selection
5. Defect effects on the signal
   - Defect orientation
   - Minimum defect length
   - Defect depth
6. Effectiveness of test
   - Lift-off variations
   - Surface conditions
   - Surface coating
   - Test piece temperature
   - Test piece geometry
   - Probe orientation
   - Probe wobble
   - Scanning speed

5.2 Surface inspections

1. Introduction
2. Examination system
   - Instrument
   - Probes
   - Calibration block
3. Equipment calibration
   - Check sensitivity
   - Calibration procedure
   - Phase adjustment
   - Gain settings
4. Inspection technique
5. Evaluation of signals
6. Sub-surface discontinuities

7. Equipment
8. Reference blocks
9. Testing of ferromagnetic materials

5.3 Welding inspection

1. Introduction
2. Examination system
   - Instrument
   - Probes
   - Calibration block
3. Equipment calibration
   - Check sensitivity
   - Phase adjustment
   - Gain settings
   - Coating thickness measurement
   - Coating thickness compensation
4. Inspection technique
   - a) Inspection of the HAZ and parent metal
   - b) Inspection of the welded surface
5. Evaluation of signals
6. Other examination techniques

5.4 Tube inspections with an internal probe

1. Introduction
   - Tube bundle heat exchangers
2. Examination system
   - Instrument
   - Internal probes
   - Calibration reference standards
3. Equipment calibration
   - Differential bobbin coil
   - Absolute bobbin coil
4. Inspection technique
5. Evaluation of signals
   - Estimate depth of discontinuities
6. Ferromagnetic tubes

5.5 Tube and bar inspections with an external probe

1. Inspection technique
   - Inspection with encircling coil
   - Inspection with surface probe & rotating workpiece
   - Inspection with surface probe for sectors
2. Calibration reference standards
   - Example of block reference
3. Equipment calibration
4. Inspection method
5. Evaluation of signals

5.6 Measuring thickness

1. Measurable thicknesses
2. Thickness of non-conductive coatings
   - Factors affecting the measurement
   - Instruments
   - Calibration reference standards
   - Instrument calibration
   - Thickness measurement
3. Thickness of conductive coatings
   - Factors influencing the measurement
   - Instrument and calibration reference blocks
   - Instrument calibration
   - Thickness measurement
4. Thickness of thin metal sheet
   - Thickness curves
   - Construction of thickness curves

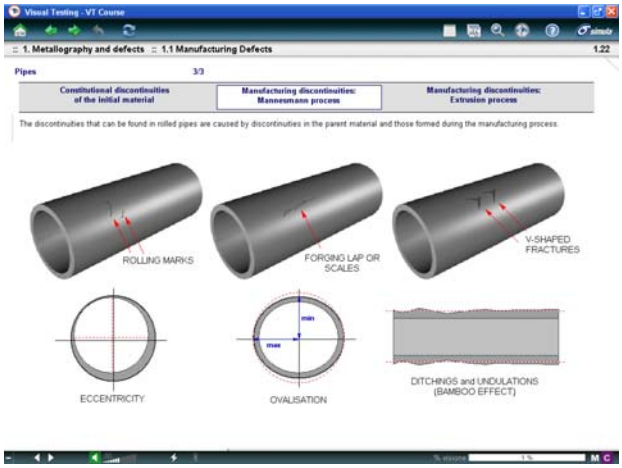
5.7 Measuring conductivity

1. Conductivity measuring
   - Factors affecting the measures
2. Instruments
3. Conductivity meters
   - Instrument calibration
   - Measurement execution
4. Measurement by general purpose meters
   - Instrument calibration
   - Choice of operating frequency

VT - VISUAL TESTING

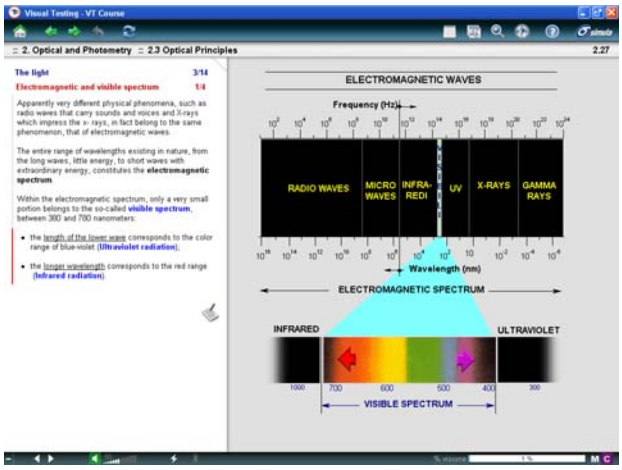
1. METALLOGRAPHY and DEFECTS

- 1.1 Manufacturing Defects
- 1.2 Welding Defects
- 1.3 Service Induced Defects
- 1.4 Metallography
- Self-evaluation Test



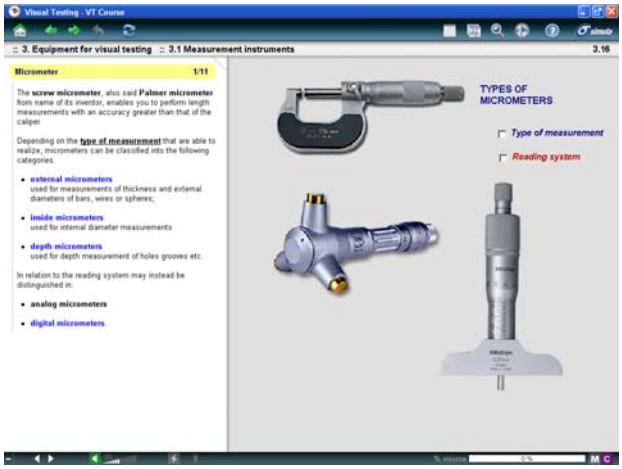
2. OPTICAL and PHOTOMETRY

- 2.1 Physiology of Vision
- 2.2 Optical Principles
- 2.3 Photometry
- Self-evaluation Test



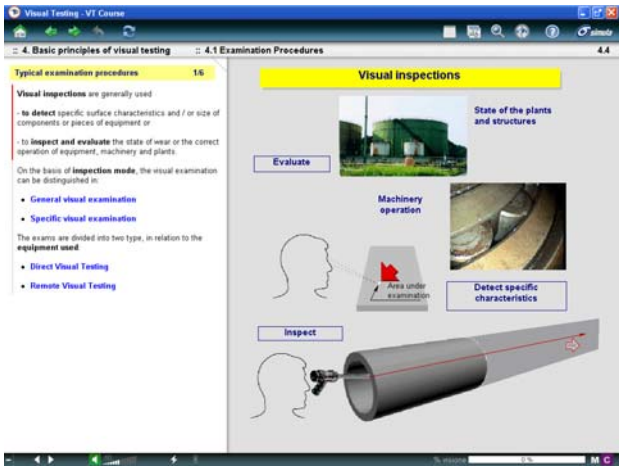
3. EQUIPMENT and TOOLS

- 3.1 Measuring Instruments
- 3.2 Temperature Indicators
- 3.3 Vision Aids Tools
- 3.4 Endoscopes
- 3.5 Other Systems
- Self-evaluation Test



4. BASIC PRINCIPLES

- 4.1 Examination Procedures
- 4.2 Basic Principles of Examination
- 4.3 Safety Aspect
- Self-evaluation Test

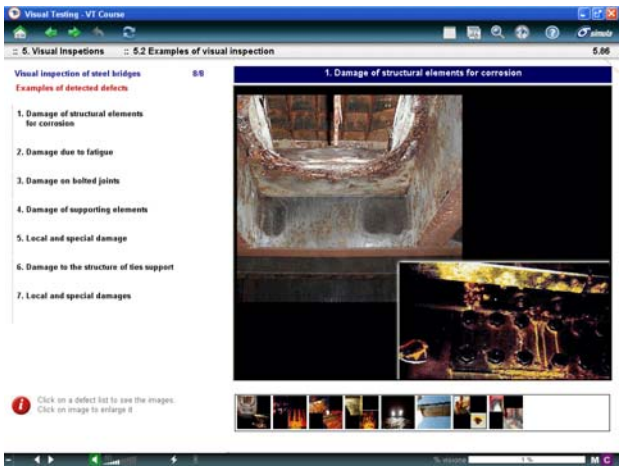


5. VISUAL INSPECTIONS

- 5.1 Visual Inspection of steel products
- 5.2 Visual Inspection of welded joints
- 5.3 Visual Inspection of connection elements
- 5.4 Visual inspection of tubes
- 5.5 Visual Inspection of valves
- 5.6 Visual Inspection of pumps
- Self-evaluation Test

6. EXAMPLES OF VISUAL INSPECTION

- 6.1 Inspection in automotive industry
- 6.2 Inspection of oil tanks
- 6.3 Visual inspection of steel bridges
- 6.4 Automotive industry
- 6.5 Power Generation and plant
- 6.6 Aerospace
- 6.7 Building and Construction



FINAL TEST

NORMS

VISUAL TESTING: DETAILED CONTENTS

1. METALLOGRAPHY and DEFECTS (>> VT)

1.1 Manufacturing Defects
- Production of Steels
- Defects in steel production
- Forging (and pressing)
- Castings
- Pipes
- Extruded
- Wire drawing
- Thermomechanical processing

1.2 Welding Defects
- Welded joints
- Welding symbols
- Defects in Welded Joints

1.3 Service Induced Defects
- Introduction
- Cracks in operation
- Loss of material
- Deformations

1.4 Metallography
- Metallographic sample
- Metallographic techniques

1.5 Self-evaluation Test
- · Manufacturing Defects
- · Welding Discontinuities
- · Service Defects
- · Metallography

2. OPTICAL and PHOTOMETRY (>> VT)

2.1 Physiology of Vision
- The vision
- Tests of visual acuity
- Parameters of vision
- Human eye sensitivity
- Visual defects

2.2 Optical Principles
- The light
- Fundamental laws of optics
- Focusing and Scattering
- Defects and limits of instruments

2.3 Photometry
- Light sources
- Propagation and light measurement
- Measurement of lighting quantity
- Sensors for photometry
- Artificial lighting

3. EQUIPMENT and TOOLS (>> VT)

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- Introduction
- Graduated metal ruler
- Goniometers
- Calipers
- Micrometer
- Test Indicators
- Welding gauge
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3.2 Temperature Indicators
- Temperature measurement
- Types of thermometers

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- Special optical systems
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3.4 Endoscopes
- Endoscopy
- Measurement methods
- Application fields

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- Computerized systems
- Image processing systems
- Automated Visual Inspection
- Robotic systems

4. BASIC PRINCIPLES (>> VT)

4.1 Examination Procedures
- Introduction
- Typical examination procedures
- Evaluation and documentation
- Standards

4.2 Basic Principles of Examination
- Introduction
- Inspector of visual testing
- Object to be examined
- Optical Equipment
- Lighting for visual examination
- Examination recording

4.3 Safety Aspect
- Introduction
- Danger from light sources
- Risk assessment
- Recommendations and Protection means

5. VISUAL INSPECTIONS (>> VT)

5.1 Visual Inspections

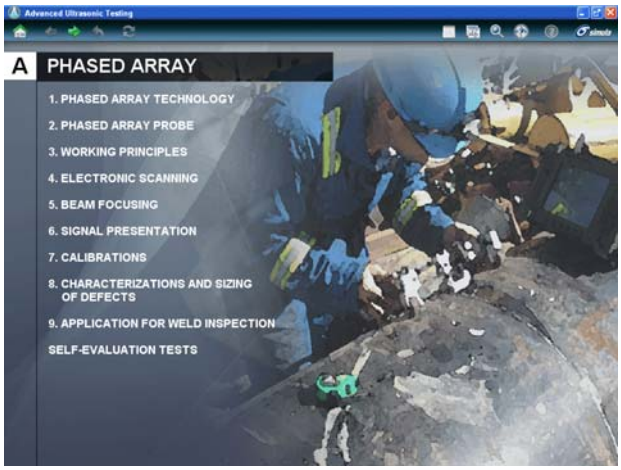
- Visual Inspection of steel products
- Visual Inspection of welded joints
- Visual Inspection of connection elements
- Visual inspection of tubes
- Visual Inspection of valves
- Visual Inspection of pumps

5.2 Examples of Visual Inspections

- Inspection in automotive industry
- Inspection of oil tanks
- Visual inspection of steel bridges
- Automotive industry
- Power Generation and plant
- Aerospace
- Building and Construction

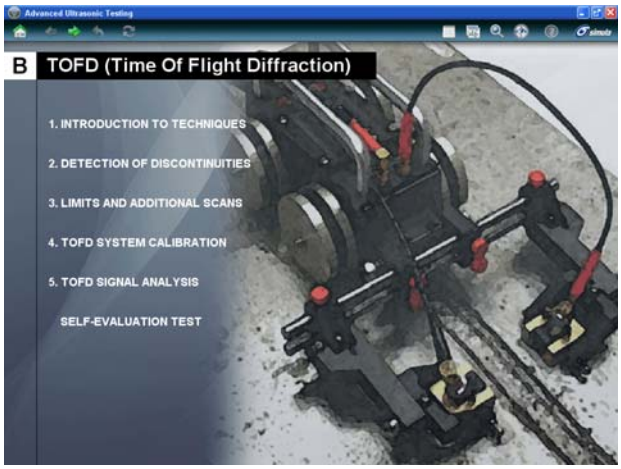
AUT - AUTOMATED ULTRASONIC TESTING (Phased Array & TOFD)

1. PHASED ARRAY



- 1.1 Phased array technology
- 1.2 Phased array probe
- 1.3 Working principles
- 1.4 Electronic scanning
- 1.5 Beam focusing
- 1.6 Signal presentation
- 1.7 Calibrations
- 1.8 Characterizations of defects
- 1.9 Application for weld inspection
- Self-evaluation tests
- **SimSCAN**

2. TOFD



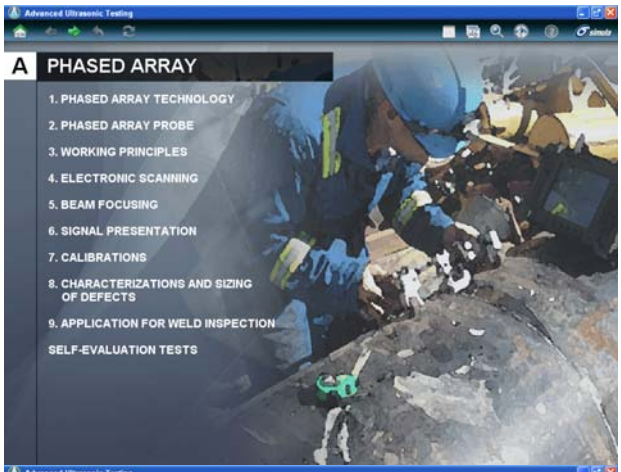
- 2.1 Introduction to techniques
- 2.2 Detection of discontinuities
- 2.3 Limits and additional scans
- 2.4 TOFD system calibration
- 2.5 TOFD signal analysis
- Self-evaluation test
- **TOFD Images**

AUTOMATED ULTRASONIC TESTING: DETAILED INDEX

1. PHASED ARRAY (>> PA)

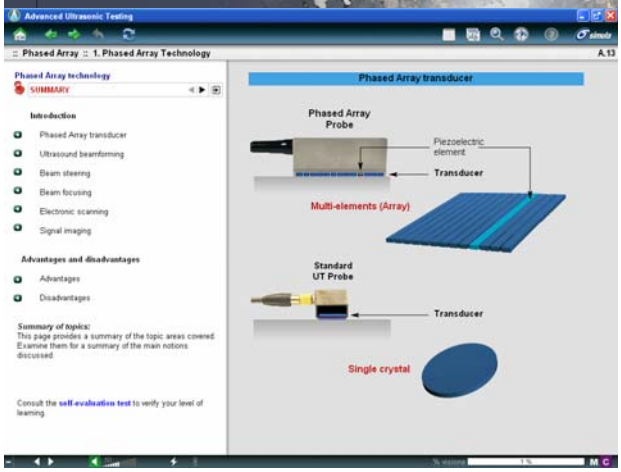
1.1 Phased array technology

- Introduction
- Phased Array transducer
- Ultrasound beamforming
- Beam steering
- Beam focusing
- Electronic scanning
- Signal imaging
- Advantages and disadvantages
- Summary



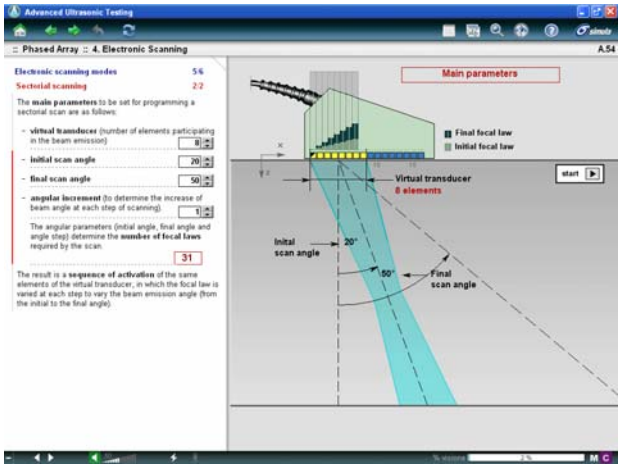
1.2 Phased array probe

- Probe structure
- Transducer
  - Transducer shape
  - Dimensional parameters
  - Wedge and types of waves
- Wedge-shaped base
  - Zero-degree wedge (Plates)
  - Wedge for complex shapes
- Summary



1.3 Working principles

- Beam forming
- Beam steering
  - Virtual transducer
  - Focal laws
  - Straight beam: Constant focal law
  - Angled beam: Linear focal law
  - Focused beam: Quadratic focal law
  - Angled and focused beam
- Acquisition cycles
  - Emitting
  - Receiving
- Summary

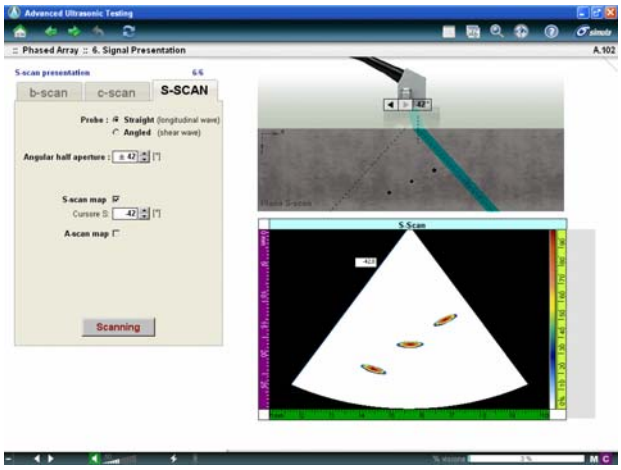


1.4 Electronic scanning

- Electronic beam steering
- Electronic scanning modes
  - Fixed angle scanning
  - Sectorial scanning
  - Combination of base scans
  - Multichannel mode

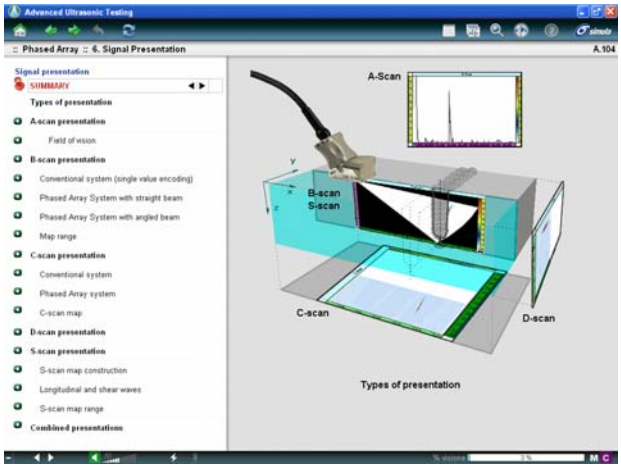
- Summary

1.5 Beam fucusing



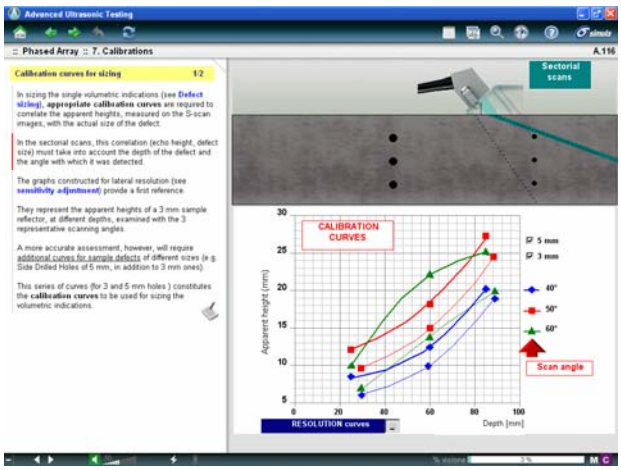
- Focusing control
- Focusing modes
  - Constant focal distance
  - Changing the focal distance
- Dynamic focusing
- Spatial resolution
  - Spatial resolution
  - Lateral resolution
  - Elevation resolution
- Probe resolution and characteristics
  - Probe frequency
  - Virtual aperture of the transducer
  - Virtual aperture and lobes
  - Summarizing table
- Summary

1.6 Signal presentation



- Types of presentation
- A-scan presentation
- B-scan presentation
- C-scan presentation
- D-scan presentation
- S-scan presentation
- Combined presentations
- Summary

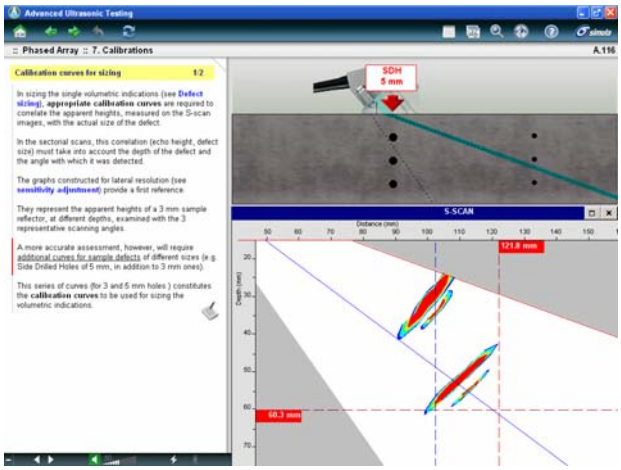
1.7 Calibrations



- Introduction
- Calibration block
- Sensitivity adjustment
- Construction of DAC curves
- Determining the lateral resolutions
- Calibration curves for sizing
- Summary
- Standard reference

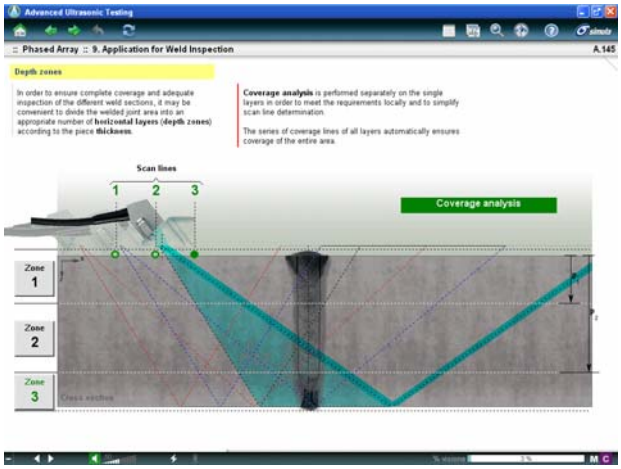
1.8 Characterizations of defects

- Introduction
- Types of defects
- Defect sizing
- Defect position
- Summary



1.9 Application for weld inspection

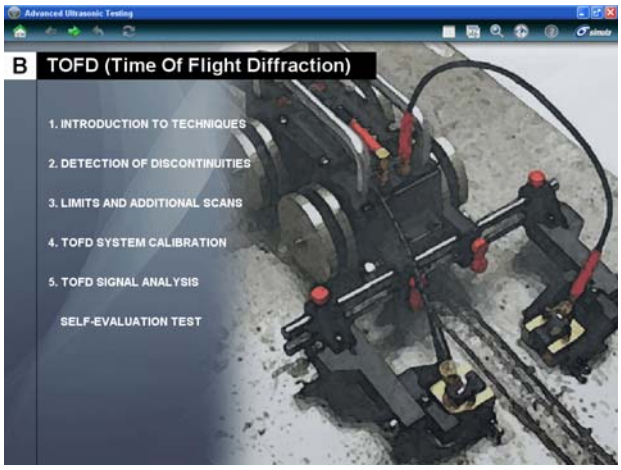
- Inspection with Phased Array
- Probe movement
- Scan lines
- Depth zones
- Multi-channel mode (virtual probe)
- Gate setting
- Focusing for welding
- Inspection speed
- Scan plan
- Summary



Self-evaluation Test

- Phased Array technology
- Phased Array probe
- Working principles
- Electronic scanning
- Beam focusing
- Signal presentation
- Calibrations
- Characterisations of defects

2. TOFD (Time Of Flight Diffraction) (>> TOFD)



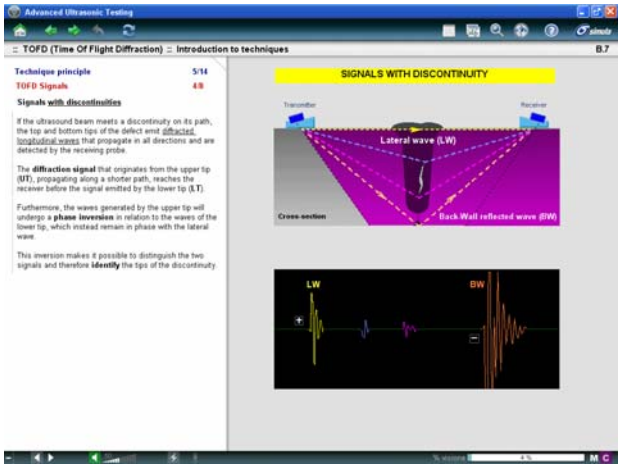
2.1 Introduction to techniques

- Technique principle
  - TOFD Signals
  - Types of waves and signals produced
  - Sizing a discontinuity
  - Scan zones and dead zones
  - Suitable scan materials

  Summary

- Advantages and disadvantages of TOFD
  - Advantages of TOFD
  - Disadvantages of TOFD

  Summary
- Data visualization
  - A-scan presentation
  - B-scan presentation
  - Summary

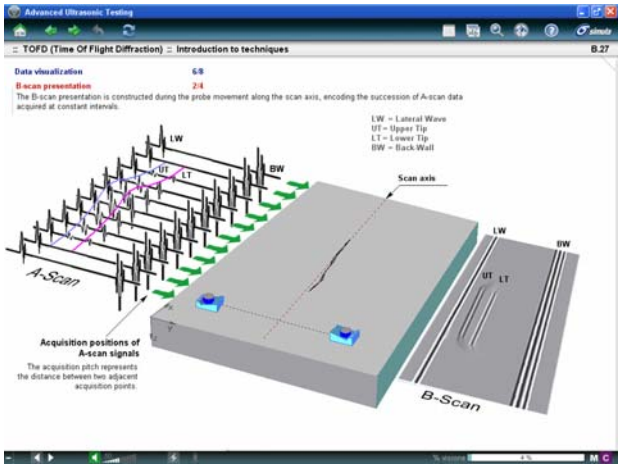


2.2 Detection of discontinuities

- Defect inspection
  - Scan types
  - Non-parallel scan
  - Parallel scan
  - Combined scans

  Summary
- Defect characterisation
  - Phase relationships between signals
  - Types of discontinuity

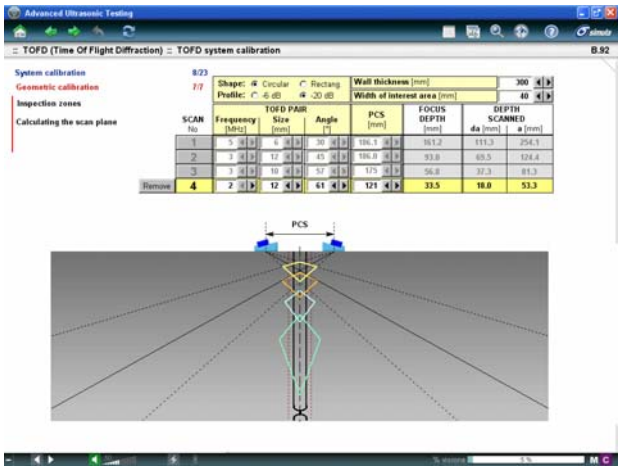
  Summary
- Defect sizing
  - Depth calculation
  - Height calculation
  - Measuring time of flight
  - Calculation time of flight
- Summary



2.3 Limits and additional scans

- Limitations of the technique
  - Locating accuracy
  - Calculation error in locating
  - Spatial resolution
  - Dead zones
  - Calculating spatial resolution and dead zone
- Additional scans
  - Scans with different frequencies
  - Scans with different emission angles
  - Scans with offset distances

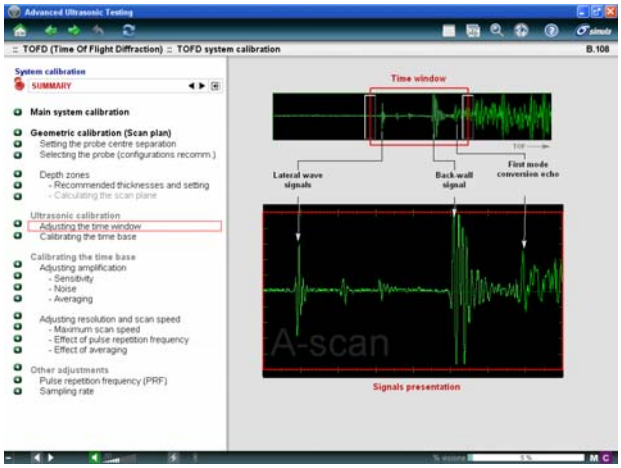
  Summary



2.4 TOFD system calibration

- TOFD system structure
  - Operation and characteristics
  - Ultrasound probes

  Summary
- System calibration
  - Geometric calibration
  - Ultrasonic calibration
  - Calibrating the acquisition system
  - Other adjustments
- Reference blocks
- Image quality
  - Basic requirements of TOFD image
  - TOFD image anomalies
- Summary

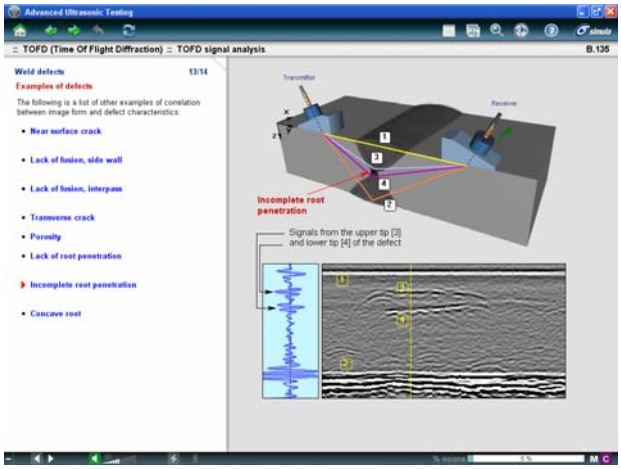


2.5 TOFD signal analysis

- Introduction
- Weld defects
  - Examples of defects

  Summary
- Sizing defects
  - Measuring depth and height
  - Measuring length
  - Examples of sizing

  Summary
- TOFD references



Self-evaluation Test

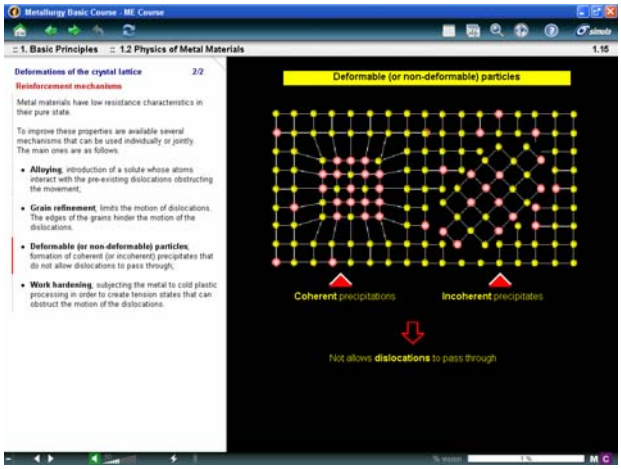
- Introduction to techniques
- Detection of discontinuities
- Limits and additional scans
- TOFD system calibration
- TOFD signal analysis

e-mail: simula@simula.it web-site: www.simula.it

ME - METALLURGY BASIC COURSE

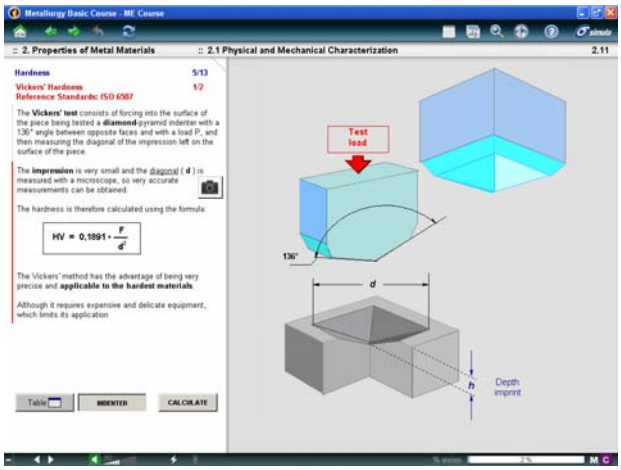
1. BASIC PRINCIPLES

- 1.1 Chemical Systems
- 1.2 Physics of Metal Materials
- 1.3 Phase Diagram
- 1.4 Phase Diagram of Binary Metal Alloys
- 1.5 Process Metallurgy
- 1.6 Heat Treatments
- Self-evaluation Tests



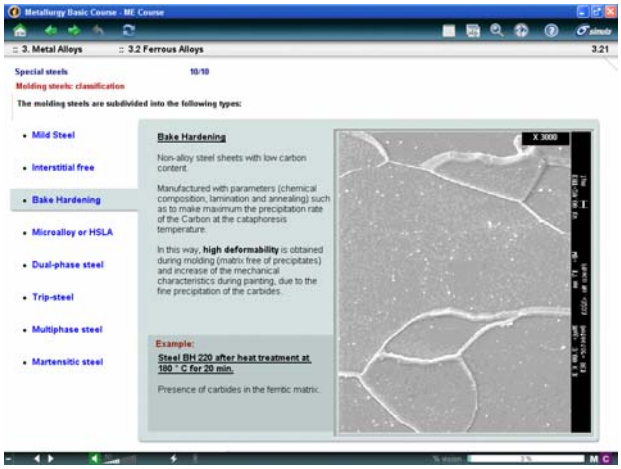
2. PROPERTIES OF METAL MATERIALS

- 2.1 Physical and mechanical characterization
- 2.2 Sample preparation
- 2.3 Test procedures and reference standards
- 2.4 Test results and suitability for use
- Self-evaluation Tests

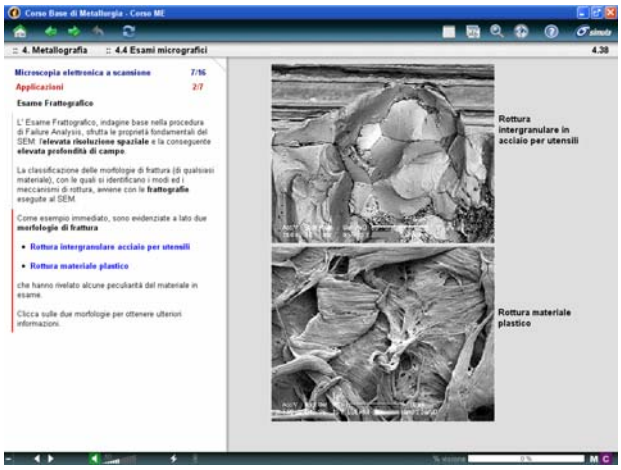


3. METAL ALLOYS

- 3.1 Introduction
- 3.2 Ferrous Alloys
- 3.3 Non-Ferrous Alloys
- Self-evaluation Tests



4. METALLOGRAPHY



- 4.1 Metallographic Techniques
- 4.2 Sample Preparation
- 4.3 Preparation Techniques
- 4.4 Micrographic Examinations
- 4.5 Characteristic Structures of Ferrous Materials
- 4.6 Test Procedures and Reference Standards
- 4.7 Test Results and Suitability for Use of Materials
- 4.8 Non-destructive Testing

- Self-evaluation Tests

METALLURGY BASIC COURSE: DETAILED INDEX

1. BASIC PRINCIPLES (>> ME)

1.1 Chemical Systems
- Homogeneous and heterogeneous systems
- Chemical-physics of metallurgical processes

1.2 Physics of Metal Materials
- Structure of matter
- Solidification metals and alloys
- Crystal lattices
- Solid solutions
- Deformations of the crystal lattice
- Solid state transformations

1.3 Phase Diagram
- Cooling curve of a pure metal
- Solubility in the liquid state
- Insolubility in the solid state

1.4 Phase Diagram of Binary Metal Alloys
- General rules of interpretation
- Iron-Carbon Diagram
  - Hypoeutectoid steel
  - Hypereutectoid steel
  - Eutectoid steel
  - Hypoeutectic cast iron
  - Hypereutectic cast iron
  - Structural transformations
  - Critical points
- Addition of Elements

1.5 Process Metallurgy
- Metallurgical processes
- Production of Carbon Steels
  - Production of Cast Iron
  - Refining
  - Casting and Solidification
  - Rolling

1.6 Heat Treatments
- Introduction
  - Heat treatment steps
  - Critical points
  - Thermal transformations
  - Cooling rate
  - TTT and CCT Curve (or Bain curve)
  - Steel hardenability
- Kinetics transformation of the steel structure
  - Austenite
  - Ferrite

  - Perlite
  - Cementite
  - Bainite
  - Martensite
- Type of thermal treatments
- Heat treatments at temperatures above critical points
  - Full Annealing
  - Isothermal annealing
  - Coalescence annealing
  - Normalisation
  - Quenching
- Treatments without phase variations
  - Tempering
  - Softening annealing
  - Relaxation
- Quench and tempering
- Surface heat treatments
  - Induction hardening
  - Thermochemical diffusion treatments
  - Cementation
  - Nitriding
  - Comparison Cementation-Nitriding

Self-evaluation Tests

2. PROPERTIES OF METAL MATERIALS (>> ME)

2.1 Physical and mechanical characterization

- Mechanical properties
- Tensile strength
- Hardness
  - Brinell Hardness
  - Vickers Hardness
  - Rockwell Hardness
  - Microhardness
- Resiliency
  - Test equipment
  - Transition ductile-brittle
  - Transition temperature
  - Resilience test
  - Test parameters
  - Izod impact strength test
- Creep (Cold flow)
- Fatigue resistance
  - Fatigue failures
  - Typical aspect of a fatigue fracture
  - Fatigue tests
  - Wohler's curve
  - Fatigue limit
- Surface roughness
  - Roughness parameters
  - Roughness measurement

2.2 Sample preparation

- Sampling for mechanical tests
  - Definitions
  - Preparation and identification of the samples
- Location and preparation of samples
  - Flat products
  - Long products
  - Tubes

2.3 Test procedures and reference standards

- Test procedures and standards
- Test standards
- Measurement uncertainty
  - Possible factors of uncertainty
  - Types of measurement uncertainty
  - Expression of measurement uncertainty

2.4 Test results and suitability for use

- Use of test results
- Design mechanical parts
  - Mechanical tests
  - Tensile strength
  - Traction stiffness
  - Compressive strength

  - Hardness measurement
  - Resistance to torsion, bending
  - Resistance to shear stresses
  - Resistance to crack propagation
  - Resistance to fatigue
  - Resistance to creep
- Environmental effects on mechanical properties
  - Stress Corrosion Cracking
  - Hydrogen Induced Cracking
  - Corrosion Fatigue
  - Resistance to shock
- Manufacturing process
  - Criticality of the transformation
  - Mechanical properties and transformation
  - Controls and Testing
- Failure Analysis and Life Assessment
  - Life assessment
  - Failure analysis

Self-evaluation Tests

3. METAL ALLOYS (>> ME)

3.1 Introduction

3.2 Ferrous Alloys

- Steel grades
  - EN designation steels
  - AISI classification
- Classification based on alloy elements
- Classification according to applications
- Structural steels
  - General purpose steel
  - Weldable steels
- Special steels
  - Nitriding steels
  - Cement steels
  - Self tempering steels
  - Tool steels
  - Steels for rolling bearings
  - Spring steels
  - Molding steels
- Stainless steels
- Casting steels
- Cast Irons

3.3 Non-Ferrous Alloys

- Aluminum Alloys
  - Characteristic structures
  - Alloy elements and features
  - Influence of alloying elements
  - Aluminum Industrial Alloys
- Magnesium Alloys
- Titanium Alloys
- Copper Alloys
- Nickel Alloys
- Cobalt Alloys

Self-evaluation Tests

4. METALLOGRAPHY (>> ME)

4.1 Metallographic Techniques

4.2 Sample Preparation

- Metallographic sample
- Basic operations
  - Sectioning or cutting
  - Resin encapsulation
  - Grinding
  - Polishing
  - Chemical etching
- Metallographic replicas

4.3 Preparation Techniques

- Ferrous alloys
- Anti-friction alloys
- Aluminum alloys
- Copper alloys
- Magnesium alloys
- Nickel alloys
- Titanium alloys
- Zinc alloys

4.4 Micrographic Examinations

- Optical microscopy
- Scanning Electron Microscopy
  - Components
  - Operation principle
  - Related technique
  - Metallurgical application
  - Evolution of microscopy techniques
  - Evolution of microanalysis techniques

4.5 Characteristic Structures of Ferrous Materials

- Austenite
- Ferrite
- Cementite
- Perlite
- Martensite
- Bainite
- Graphite

4.6 Test procedures and reference standards

- Test procedures and standards
- Standardization levels

4.7 Test results and suitability for Use of Materials

- Use of the test results
- Microstructural examinations
  - Band structure classification in laminates
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Self-evaluation Tests

CO - CORROSION BASIC PRINCIPLES

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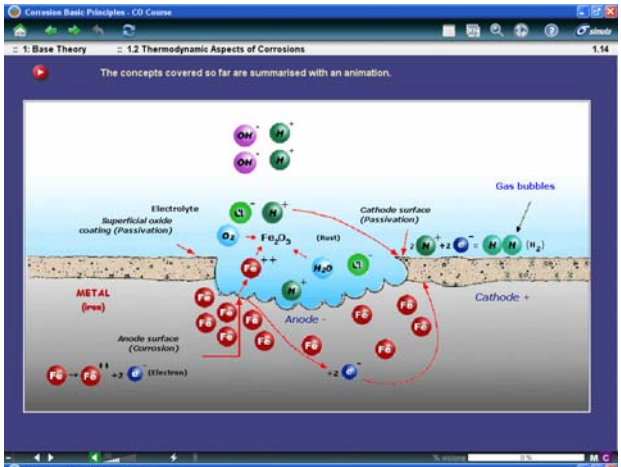
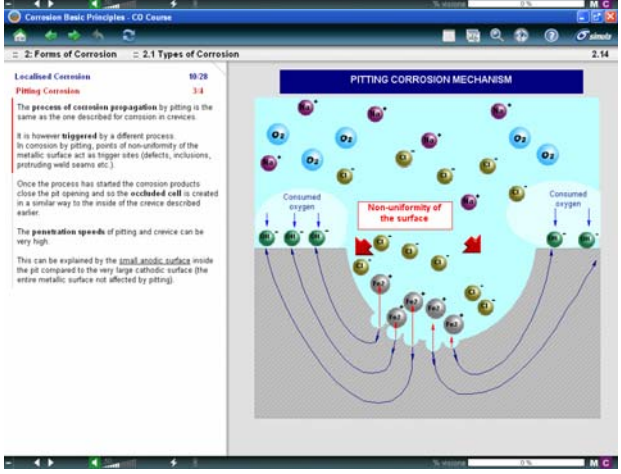
- 1.1 Introduction
- 1.2 Thermodynamic Aspects
- 1.3 Kinetics Principles
- 1.4 Examples of Corrosion Cells in the Pipeline
- 1.5 Internal Corrosion Parameters
- 1.6 Corrosive Environments
- Self-evaluation Test



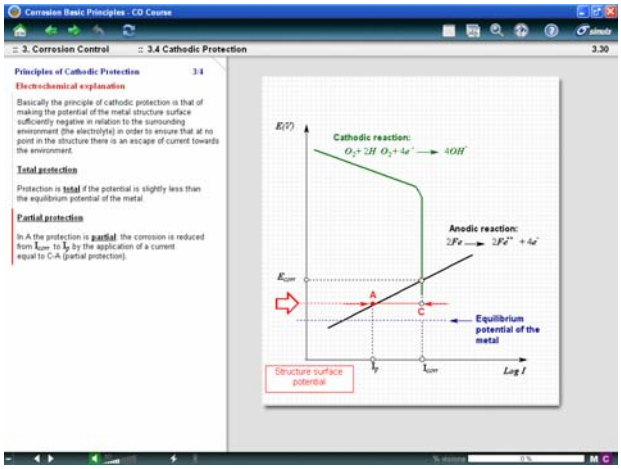
2. FORMS OF CORROSION

- 2.1 Types of Corrosion
- 2.2 Examination of Real Cases
- Self-evaluation Test



3. INTRODUCTION TO CORROSION CONTROL

- 3.1 Introduction
- 3.2 Protection from the Internal Corrosion
- 3.3 Passive Protection (Coatings)
- 3.4 Cathodic Protection
- Self-evaluation Test



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Self-evaluation Test

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