# MT

# MAGNETIC PARTICLE TESTING TOPICAL OUTLINES

## Magnetic Particle Testing Level I Topical Outline

1.0 **Introduction**
- 1.1 History of magnetic particle testing (MT)
- 1.2 Purpose of NDT
- 1.3 Overview of basic NDT methods
- 1.4 Training and certification process
- 1.5 MT process overview
- 1.6 Advantages and limitations
- 1.7 Terminology

2.0 **Principles of Magnets and Magnetic Fields**
- 2.1 Theory of magnetic fields
  - 2.1.1 Earth's magnetic field
  - 2.1.2 Electrical fields
  - 2.1.3 Magnetic fields around magnetized materials
- 2.2 Theory of magnetism
  - 2.2.1 Domain theory
  - 2.2.2 Materials
  - 2.2.3 Flux density
  - 2.2.4 Law of magnetism
  - 2.2.5 Properties of magnetic fields
  - 2.2.6 Flux leakage
  - 2.2.7 Hysteresis of magnetism
  - 2.2.8 Measurement of fields

3.0 **Material Preparation and Discontinuities**
- 3.1 Component preparation
- 3.2 Precleaning
  - 3.2.1 Solvent
  - 3.2.2 Chemical
  - 3.2.3 Mechanical
- 3.3 Coatings
- 3.4 Surface discontinuities
- 3.5 Subsurface discontinuities

4.0 **Circular Magnetism**
- 4.1 Field produce in a straight conductor
- 4.2 Field within materials
  - 4.2.1 Right-hand rule
  - 4.2.2 Fields in materials
  - 4.2.3 Indication geometry
- 4.3 Direct magnetic induction
- 4.4 Indirect magnetic induction
- 4.5 Strength of fields
- 4.6 Field detection
- 4.7 Advantages/disadvantages

5.0 **Longitudinal Magnetism**
- 5.1 Field produced by coil
- 5.2 Field within materials
  - 5.2.1 Magnetic field induction
  - 5.2.2 Fields in materials
  - 5.2.3 Indication geometry
- 5.3 Strength of fields
- 5.4 Field detection
- 5.5 Advantages/disadvantages

6.0 **Sources of Magnetic Fields**
- 6.1 Magnets
- 6.2 Types of magnetizing current
  - 6.2.1 Direct current
  - 6.2.2 Alternating current
  - 6.2.3 Advantages/disadvantages

7.0 **Inspection Materials**
- 7.1 Wet particles
- 7.2 Dry particles
- 7.3 Application of particles

8.0 **Principles of Demagnetization**
- 8.1 Residual magnetism
- 8.2 Reasons for demagnetization
- 8.3 Longitudinal and circular residual fields
- 8.4 Basic principles of demagnetization
- 8.5 Residual and coercive force
- 8.6 Methods of demagnetization
- 8.7 Measurement of results

9.0 **Equipment**
- 9.1 Equipment selection considerations
  - 9.1.1 Type of magnetizing current
  - 9.1.2 Location and nature of test
  - 9.1.3 Test materials
  - 9.1.4 Purpose of test
  - 9.1.5 Area inspected

- 9.2 Stationary equipment
- 9.3 Mobile equipment
- 9.4 Portable equipment
- 9.5 Multidirectional equipment
- 9.6 Automatic equipment
- 9.7 Demagnetization equipment
- 9.8 Light sources
  - 9.8.1 White light
  - 9.8.2 UV-A light
  - 9.8.3 Ambient light
  - 9.8.4 Measurement devices
- 9.9 Field measurement devices
  - 9.9.1 Field direction
  - 9.9.2 Field strength
- 9.10 Materials
  - 9.10.1 Visible particles
  - 9.10.2 Fluorescent particles
  - 9.10.3 Wet versus dry
  - 9.10.4 Bath properties and concentrations
  - 9.10.5 Portable materials

**10.0 Selecting Proper Methods of Magnetization**

- 10.1 Procedure and written instructions
- 10.2 Industry standards
  - 10.2.1 Welds
  - 10.2.2 Pipe
  - 10.2.3 Aerospace
  - 10.2.4 Other users

**11.0 Product and flaw stages**

- 11.1 Inherent stage
- 11.2 Primary processing stage
- 11.3 Secondary processing stage
- 11.4 In-service stage
- 11.5 Types of discontinuities detected by MT
  - 11.5.1 Inclusions
  - 11.5.2 Blowholes
  - 11.5.3 Porosity
  - 11.5.4 Flakes
  - 11.5.5 Cracks
  - 11.5.6 Pipes
  - 11.5.7 Laminations
  - 11.5.8 Laps
  - 11.5.9 Forging bursts
  - 11.5.10 Voids

**12.0 Magnetic Particle Testing Indications and Interpretations**

- 12.1 Human factors
- 12.2 View conditions
- 12.3 Continuity of inspection
- 12.4 Lighting
- 12.5 Component use and condition
- 12.6 Purpose of test
- 12.7 Interpretation of indication
  - 12.7.1 Relevant versus nonrelevant
  - 12.7.2 Surface versus subsurface indications
- 12.8 Evaluation
  - 12.8.1 Criteria
  - 12.8.2 Acceptance/rejection
- 12.9 Postcleaning and protection
- 12.10 Documentation of test

## Magnetic Particle Testing Level II Topical Outline

**1.0 Review**

- 1.1 Basic principles
- 1.2 Basic magnetic particle process
- 1.3 Equipment
- 1.4 Terminology
- 1.5 Test factors
- 1.6 Safety
- 1.7 Training and certification processes

**2.0 Principles**

- 2.1 Theory
  - 2.1.1 Flux patterns
  - 2.1.2 Frequency and voltage factors
  - 2.1.3 Current calculations
  - 2.1.4 Surface flux strength
  - 2.1.5 Subsurface effects
- 2.2 Magnets and magnetism
  - 2.2.1 Distance factors versus strength of flux
  - 2.2.2 Internal and external flux patterns
  - 2.2.3 Phenomenon action at the discontinuity
  - 2.2.4 Heat effects on magnetism
  - 2.2.5 Material hardness versus magnetic retention
- 2.3 Flux fields
  - 2.3.1 Direct current
    - 2.3.1.1 Depth of penetration factors
    - 2.3.1.2 Source of current
  - 2.3.2 Direct pulsating current
    - 2.3.2.1 Similarity to direct current
    - 2.3.2.2 Advantages
    - 2.3.2.3 Typical fields
  - 2.3.3 Alternating current
    - 2.3.3.1 Cyclic effects
    - 2.3.3.2 Surface strength characteristics
    - 2.3.3.3 Safety precautions
    - 2.3.3.4 Voltage and current factors
    - 2.3.3.5 Source of current
- 2.4 Effects of discontinuities on materials
  - 2.4.1 Design factors
    - 2.4.1.1 Mechanical properties
    - 2.4.1.2 Part use
  - 2.4.2 Relationship to load-carrying ability
  - 2.4.3 Cyclic loading issues

- 2.5 Magnetization by means of electric current
  - 2.5.1 Circular techniques
    - 2.5.1.1 Current determinations
    - 2.5.1.2 Depth-factor considerations
    - 2.5.1.3 Precautions – safety and overheating
    - 2.5.1.4 Contact prods and plates
      - 2.5.1.4.1 Requirements for prods and plates
      - 2.5.1.4.2 Current-carrying capabilities
    - 2.5.1.5 Discontinuities commonly detected
  - 2.5.2 Longitudinal technique
    - 2.5.2.1 Principles of induced flux fields
    - 2.5.2.2 Geometry of part to be inspected
    - 2.5.2.3 Shapes and sizes of coils
    - 2.5.2.4 Use of coils and cables
      - 2.5.2.4.1 Strength of field
      - 2.5.2.4.2 Current directional flow versus flux field
      - 2.5.2.4.3 Shapes, sizes, and current capacities
    - 2.5.2.5 Determining proper current
      - 2.5.2.5.1 Types of current required
      - 2.5.2.5.2 Current evaluation
      - 2.5.2.5.3 Measuring current
    - 2.5.2.6 Yokes
    - 2.5.2.7 Discontinuities commonly detected
- 2.6 Selecting the proper method of magnetization
  - 2.6.1 Alloy, shape, and condition of part
  - 2.6.2 Type of magnetizing current
  - 2.6.3 Direction of magnetic field
  - 2.6.4 Sequence of operations
  - 2.6.5 Value of flux density

**3.0 Principles of Demagnetization**

- 3.1 Residual magnetism
- 3.2 Reasons for demagnetization
- 3.3 Longitudinal and circular residual fields
- 3.4 Basic principles of demagnetization
- 3.5 Residual and coercive force
- 3.6 Methods of demagnetization
- 3.7 Measurement of results

**4.0 Equipment**

- 4.1 Portable equipment
  - 4.1.1 Reason for portable equipment
  - 4.1.2 Capabilities of portable equipment
  - 4.1.3 Similarity to stationary equipment
- 4.2 Mobile equipment
  - 4.2.1 Reason for mobile equipment
  - 4.2.2 Capabilities of mobile equipment
  - 4.2.3 Similarity to stationary equipment
- 4.3 Stationary equipment
  - 4.3.1 Requirements for automation
  - 4.3.2 Sequential operations
  - 4.3.3 Control and operation factors
  - 4.3.4 Alarm and rejection mechanisms
- 4.4 Multidirectional equipment
  - 4.4.1 Capabilities
  - 4.4.2 Sequential operations
  - 4.4.3 Control and operation factors
  - 4.4.4 Applications
- 4.5 Liquids and powders
  - 4.5.1 Liquid requirements as a particle vehicle
  - 4.5.2 Safety precautions
  - 4.5.3 Temperature needs
  - 4.5.4 Powder and paste contents
  - 4.5.5 Mixing procedures
  - 4.5.6 Need for accurate proportions
  - 4.5.7 Bath-strength factors and strength quality
- 4.6 Light sources
  - 4.6.1 White light
  - 4.6.2 UV-A light
  - 4.6.3 Ambient light
  - 4.6.4 Measurement devices
  - 4.6.5 Safety

**5.0 Types of Discontinuities**

- 5.1 In castings
- 5.2 In ingots
- 5.3 In wrought sections and parts
- 5.4 In welds

**6.0 Magnetic Particle Testing Indications and Interpretations**

- 6.1 Human factors
- 6.2 Continuity of inspection
- 6.3 View conditions
- 6.4 Lighting
- 6.5 Component use and condition
- 6.6 Purpose of test
- 6.7 Interpretation of indication
  - 6.7.1 Relevant versus nonrelevant
  - 6.7.2 Surface versus subsurface indications
- 6.8 Evaluation
  - 6.8.1 Criteria
  - 6.8.2 Acceptance/rejection
- 6.9 Postcleaning and protection
- 6.10 Documentation of test

**7.0 Procedure Development**

- 7.1 Use of standards (e.g., ASTM, ASME)
- 7.2 Need for standards and references
- 7.3 Part considerations
  - 7.3.1 History of part
  - 7.3.2 Manufacturing process
  - 7.3.3 Possible causes of defect
  - 7.3.4 Usage of part
  - 7.3.5 Acceptance/rejection criteria
- 7.4 Use of tolerances
- 7.5 Validation processes

**8.0 Quality Control of Equipment and Processes**
- 8.1 Equipment preventive maintenance
- 8.2 Vehicle bath maintenance and strength checks
  - 8.2.1 Settling test process
  - 8.2.2 Other bath-strength tests
- 8.3 Lighting intensity checks
  - 8.3.1 UV light
  - 8.3.2 White light
- 8.4 Field strength validation devices
- 8.5 Residual field checking devices

## Magnetic Particle Testing Level III Topical Outline

**1.0 Principles/Theory**
- 1.1 Principles of magnets and magnetic fields
  - 1.1.1 Theory of magnetic fields
  - 1.1.2 Theory of magnetism
  - 1.1.3 Terminology associated with MT
- 1.2 Characteristics of magnetic fields
  - 1.2.1 Bar magnet
  - 1.2.2 Ring magnet

**2.0 Equipment/Materials**
- 2.1 MT equipment
  - 2.1.1 Equipment selection considerations
  - 2.1.2 Manual inspection equipment
  - 2.1.3 Medium- and heavy-duty equipment
  - 2.1.4 Stationary equipment
  - 2.1.5 Mechanized inspection equipment
- 2.2 Inspection materials
  - 2.2.1 Wet particle technique
  - 2.2.2 Dry particle technique

**3.0 Technique**
- 3.1 Magnetization by means of electric current
  - 3.1.1 Circular field
    - 3.1.1.1 Field around a straight conductor
    - 3.1.1.2 Right-hand rule
    - 3.1.1.3 Field in parts through which current flows
    - 3.1.1.4 Methods of inducing current flow in parts
    - 3.1.1.5 Discontinuities commonly indicated by circular field
    - 3.1.1.6 Applications of circular magnetization
  - 3.1.2 Longitudinal field
    - 3.1.2.1 Field direction
    - 3.1.2.2 Discontinuities commonly indicated by longitudinal techniques
    - 3.1.2.3 Applications of longitudinal magnetization
- 3.2 Selecting the proper method of magnetization
  - 3.2.1 Alloy, shape, and condition of part
  - 3.2.2 Type of magnetizing field
  - 3.2.3 Direction of magnetic field
  - 3.2.4 Sequence of operation
  - 3.2.5 Value of flux density
- 3.3 Demagnetization
  - 3.3.1 Reasons for requiring demagnetization
  - 3.3.2 Methods of demagnetization

**4.0 Interpretation/Evaluation**
- 4.1 Continuity of inspection
- 4.2 MT indications and interpretations
- 4.3 Effects of discontinuities on materials and types of discontinuities indicated by MT
- 4.4 MT procedures, codes, standards, and specifications

**5.0 Procedures**
- 5.1 Foreword (scope, reference documents)
- 5.2 Personnel
- 5.3 Apparatus to be used, including settings
- 5.4 Product (description or drawing, including area of interest and purpose of the test)
- 5.5 Test conditions, including preparation for testing
- 5.6 Detailed instructions for application of the test
- 5.7 Recording and classifying the results of the test
- 5.8 Reporting the results

**6.0 Safety and Health**
- 6.1 Toxicity
- 6.2 Electrical
- 6.3 Flammability
- 6.4 Precautions for UV
- 6.5 Material safety data sheets (MSDS)
- 6.6 Precautions for UV

### MAGNETIC PARTICLE TESTING LEVEL I, II, AND III TRAINING REFERENCES


ASM. 1989. *Nondestructive Evaluation and Quality Control.* vol. 17. *ASM Handbook.* Metals Park, OH: ASM International.

ASNT, latest edition, *ASNT Level II Study Guide: Magnetic Particle Testing Method,* Columbus, OH: American Society for Nondestructive Testing Inc.*

ASNT, latest edition, *ASNT Level III Study Guide: Magnetic Particle Testing Method,* Columbus, OH: American Society for Nondestructive Testing Inc.*

ASNT, latest edition, *ASNT Questions & Answers Book: Magnetic Particle Testing,* Columbus, OH: American Society for Nondestructive Testing Inc.*

ASNT. 2008. *Magnetic Particle Testing. 3rd ed. vol. 8. Nondestructive Testing Handbook.* Columbus, OH: American Society for Nondestructive Testing Inc.*

ASNT. 2015. *Magnetic Particle Testing Classroom Training Book,* PTP Series. Columbus, OH: American Society for Nondestructive Testing Inc.*

ASNT. 2015. *Magnetic Particle Testing Programmed Instruction Book,* PTP Series. Columbus, OH: American Society for Nondestructive Testing Inc.*

ASTM, 2021, *Annual Book of ASTM Standards,* Vol. 03.03 *Nondestructive Testing,* ASTM International, Philadelphia, PA.

AWS, latest edition, *Welding Handbook,* Vol. 1, American Welding Society, Miami, FL.

Betz, C. 2000. Principles of Magnetic Particle Testing. Chicago, IL: Magnaflux Corp.

Mix, P., 2005. Introduction to Nondestructive Testing: A Training Guide, second edition, John Wiley & Sons, New York.


* Available from The American Society for Nondestructive Testing Inc., Columbus, OH.