COMPENDIUM OF INDIAN STANDARDS ON

NON-DESTRUCTIVE TESTING IN METALLURGY

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Introduction

Non-destructive testing (**NDT**) is the testing of materials, for surface or internal flaws or metallurgical condition, without interfering in any way with the integrity of the material or its suitability for service. NDT techniques play a critical role in the field of metallurgy and ensure the structural integrity and serviceability of metallic products without impairing their performance or usability.

This compendium provides a list and brief description of Indian Standards related to Non-Destructive Testing (NDT) methods relevant to the metallurgical field. These standards have been formulated by MTD 21, Non-Destructive Testing Sectional Committee of the Metallurgical Engineering Department, Bureau of Indian Standards. This document aims to serve as a ready reference for industries, researchers, quality control engineers, and other stakeholders.

Chapter 1: Magnetic Particle Testing

Magnetic Particle Testing (MPT) is used to detect surface and near-surface flaws in ferromagnetic materials. This technique is widely used in inspection of welds, forgings, castings, and machined components. It works by applying a magnetic field and then dusting the surface with magnetic particles that reveal discontinuities.

Indian Standards on Magnetic Particle Testing:

i) **IS 3703 : 2023 – Recommended Practice for Magnetic Particle Flaw Detection**
This standard offers comprehensive guidance on both dry and wet magnetic particle flaw detection techniques for detecting cracks and other discontinuities which are open to surface or just below the surface in ferromagnetic materials. It includes information on magnetizing techniques, particle types (wet or dry), application methods, and flaw interpretation. The practice helps identify defects such as fatigue cracks, laps, and inclusions, supporting reliable assessments in manufacturing and maintenance inspections.

ii) **IS 5334 : 2014 – Magnetic Particle Flaw Detection of Welds – Code of Practice**
This standard outlines best practices for applying magnetic particle inspection to welded joints in ferromagnetic materials. It covers the full process, from surface preparation and equipment selection to magnetization methods (like prod, yoke, head-shot, and central conductor) and flaw evaluation. The guidance provided ensures accurate assessment of weld integrity and helps maintain quality standards in critical structures.

iii) **IS 6752 : 2014 – Code of Practice for Magnetic Particle Flaw Detection of Ferrous Pipes and Tubes**
This standard covers magnetic particle methods for the detection of surface/subsurface flaws in both seamless and welded ferrous pipes and tubes having an outside diameter of not less than 3 mm. It specifies media types (dry powders, wet suspensions, inks), inspection equipment, multiple magnetization methods: direct current, central conductor, prod, yoke, and coil and recommends current ranges based on pipe diameter and wall thickness.

iv) **IS 7743 : 2006 – Recommended Practice for Magnetic Particle Testing and Inspection of Steel Forgings**
This standard provides procedures for conducting magnetic particle testing on ferromagnetic steel forgings. It includes guidance on magnetization techniques, particle types, equipment calibration, and acceptance criteria. It supports quality assurance in critical applications by ensuring reliable flaw detection during manufacturing and inspection of forged components.

Chapter 2: Ultrasonic Testing

Ultrasonic Testing (UT) uses high-frequency sound waves to detect internal flaws and characterize materials. It is extensively used in quality control of steel plates, forgings, and pressure components.

Indian Standards on Ultrasonic Testing:

i) **IS 3664 : 1981– Code of Practice for Ultrasonic Pulse Echo Testing by Contact and Immersion Methods**
This standard outlines procedures for ultrasonic pulse-echo testing using A-scan for detecting discontinuities in metallic materials via contact and immersion methods. It is applicable to a range of products including castings, forgings, plates, and bars.

ii) **IS 4225 : 2021 – Steel – Ultrasonic Testing of Steel Flat Products of Thickness Equal to or Greater than 6 mm**
This standard specifies automated and manual pulse-echo ultrasonic testing methods for detecting internal discontinuities in steel flat products (6 mm to 200 mm thick). This is applicable to both alloyed and non-alloyed steel plates.

iii) **IS 11630 : 2005 – Method for Ultrasonic Testing of Steel Plates for Pressure Vessels and Special Applications**
This standard describes ultrasonic testing methods of hot-rolled heat-treated carbon and low alloy steel plates (12 mm and above) used in pressure vessels and special applications. It includes details on test frequencies, equipment setup, scanning patterns, and acceptance criteria for two grades of plates.

iv) **IS 11626 : 2005 – Recommended Practice for Ultrasonic Testing and Acceptance for Plain Carbon and Low Alloy Forging Quality Steel Blooms**
This standard describes ultrasonic inspection of forging-quality steel blooms made from plain carbon or low alloy steels (of sizes upto 300 mm × 300 mm from ingot route and 200 mm × 200 mm from continuous casting route) using straight beam, pulse-echo technique. It provides detailed acceptance criteria, equipment specifications, scanning procedures, and defect evaluation techniques.

v) **IS 18115 : 2023 — Non-Destructive Testing — Ultrasonic Testing — Characterization and Sizing of Discontinuities**
This standard specifies the general principles and techniques for characterization and sizing of previously detected discontinuities using ultrasonic testing for their evaluation against applicable acceptance criteria. It includes methods like maximum echo height, probe movement sizing, and tip diffraction and it ensures consistent evaluation of discontinuities with respect to shape, orientation, and size, supporting accurate defect assessment in NDT applications.

vi) **IS 15531 : 2004 — Recommended Practice for Ultrasonic Testing of Weld Fillets of Non-Linear Joints**
This standard describes the method for ultrasonic testing and inspection of fusion welded non-linear joints (such as set-on, set-through, T-joints, cruciform, and node joints) in materials over 6 mm thick using direct contact pulse-echo method.

vii) **IS 7343 : 1986 – Code of Practice for Ultrasonic Testing of Ferrous Welded Pipes and Tubular Products**
This standard specifies ultrasonic pulse-echo testing methods for detecting longitudinal and transverse defects in ferrous welded pipes. It is applicable to tubular products over 12 mm OD.

viii) **IS 8791 : 1978 – Code of Practice for Ultrasonic Flaw Detection of Ferritic Steel Forgings**
This standard describes ultrasonic flaw detection practices for ferritic steel forgings evaluation based on back wall echo comparisons. It emphasizes operator expertise, equipment calibration, and flaw characterization using amplitude-based classification.

ix) **IS 7666 : 1988 – Ultrasonic Examination of Ferritic Castings of Carbon and Low Alloy Steel – Recommended Procedure**
This standard recommends procedures for ultrasonic testing of carbon and low alloy ferritic steel castings. It focuses on longitudinal wave use, equipment calibration with reference blocks, and testing post heat treatment and it helps manufacturers and inspectors in evaluating casting quality.

x) **IS 6394 : 2006 – Ultrasonic Testing of Seamless Metallic Tubular Products by Contact and Immersion Methods – Code of Practice**
This standard guides ultrasonic pulse-echo testing of seamless metallic tubes using contact or immersion techniques. It defines procedures for detecting longitudinal and transverse flaws and emphasizes consistent testing on tubes with an outer-to-inner diameter ratio of less than 2.

xi) **IS 4260 : 2004 – Recommended Practice for Ultrasonic Testing of Butt Welds in Ferritic Steel**
This standard provides procedures for ultrasonic inspection of ferritic steel butt welds (eith material thickness over 5 mm) using direct contact pulse-echo reflection methods. It is used for detection, location and evaluation of reflection within the weld, heat affected zone and adjacent material.

xii) **IS 15452 : 2004 – Recommended Practice for Flaw Sizing by Ultrasonic DGS Method**
This standard describes flaw sizing in materials using Distance-Gain-Size (DGS) diagrams with A-scan presentation. It covers normal and angle beam probe usage, calibration using equivalent flaw sizes, and corrections for attenuation and transfer loss. The method estimates reflector sizes when flaws are smaller than the ultrasonic beam.

xiii) **IS 15404 : 2003 – Recommended Practice for Measuring Ultrasonic Velocity in Materials**
This standard details the procedure for measuring ultrasonic velocity using longitudinal and transverse waves. It outlines equipment, calibration, couplants, and reference materials needed for accurate measurements, supporting material characterization like elasticity and acoustic impedance, primarily for specimens over 5 mm in thickness using A-scan ultrasonic flaw detectors.

xiv) **IS 15435 : 2003 – Recommended Practice for Measuring Thickness Using Ultrasonic Method**
This standard prescribes procedures for thickness measurement using ultrasonic pulse-echo methods. It applies to materials with consistent velocity and clear back wall echo. It differentiates between absolute thickness and variation checks, explains probe types, calibration techniques, and addresses error sources in ultrasonic thickness gauging systems.

Chapter 3: Radiographic Testing

Radiographic Testing (RT) is used to view the internal structure of a component using X-rays or gamma rays. It is effective for detecting internal voids and defects in welds and castings.

Indian Standards on Radiographic Testing:

i) **IS 1182 : 1983 – Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates**
This standard provides guidance for radiographic examination of fusion-welded butt joints in steel plates. It defines two techniques: Technique A for general use, and Technique B for high-sensitivity applications.

ii) **IS 4853 : 1982 – Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes**
This standard outlines recommended practices for the radiographic inspection of fusion-welded butt joints in steel pipes (up to 50 mm wall thickness). It specifies two classes of radiographic techniques (Class A and B), based on sensitivity needs.

Chapter 4: Eddy Current Testing

Eddy Current Testing (ECT) is an electromagnetic technique primarily used for detecting surface and near-surface defects in conductive materials, particularly non-ferrous metals and round steel bars.

Indian Standards on Eddy Current Testing:

i) **IS 11612 : 2004 – Code of Practice for Eddy Current Testing of Non-Ferrous Seamless Pipes and Tubes**
This standard describes the methods for eddy current detection of defects in non-ferrous seamless pipes and tubes (outer diameter approx. 3 to 50 mm) of uniform cross-section and composition. It describes test principle using alternating current to induce eddy currents and detect defects via coil response.

ii) **IS 13190 : 1991 – Recommended Practice for Eddy Current Examination (by Rotating Probe Method) of Round Steel Bars**
This standard outlines the procedure for eddy current testing using rotating probe method to detect surface defects in round steel bars (12 mm to 63 mm diameter). It is applicable to hot rolled and bright bars, using rotating probe assembly to scan for defects like cracks, seams, laps, and scabs.

iii) **IS 14800 : 2000 – Recommended Practice for Sorting of Ferrous/Non-ferrous Materials using Electromagnetic (Eddy Current) Technique**
This standard provides recommended practices for sorting ferrous and non-ferrous materials using eddy current techniques. It covers absolute and comparative coil methods for distinguishing differences in conductivity, hardness, heat treatment, and alloy grade.

iv) **IS 6398 (Part 2) : 2020 – Non-Destructive Testing of Steel Tubes Part 2 Automated Eddy Current Testing of Seamless and Welded (Except Submerged Arc-Welded) Steel Tubes for the Detection of imperfections**
This standard specifies requirements for automated eddy current testing of seamless and welded (except SAW) steel tubes to detect imperfections. It details test techniques, reference standards, calibration, acceptance criteria, and reporting. The standard aligns with ISO 10893-2 and applies to tubes with ≥4 mm outer diameter.

Chapter 5: Liquid Penetrant Testing

Liquid Penetrant Testing (LPT) is a method for detecting surface-breaking defects in non-porous materials. It is especially effective for non-magnetic metals, and is widely used in weld and casting inspection.

Indian Standards on Liquid Penetrant Testing:

i) **IS 3658 : 1999 – Code of Practice for Liquid Penetrant Flaw Detection**
This standard provides procedures for detection of surface-breaking flaws using liquid penetrants on metals and non-porous non-metals. It covers penetrant types, dwell times, developer application and inspection, and recommends penetrant selection based on sensitivity needs and surface conditions.

ii) **IS 12889 : 1989 – Performance Evaluation of Materials Used for Liquid Penetrant Test**
This standard specifies requirements and evaluation methods for materials used in liquid penetrant testing of metals, ceramics, and plastics. It defines penetrant groups (visible, fluorescent, dual-mode) and removal methods (water washable, emulsifiable, solvent removable) and sets criteria for physical properties: flash point, removability, fluorescence, storage stability, and corrosion resistance.

Chapter 6: Leak Testing

Leak Testing is used to ensure the integrity of pressure-retaining components by detecting leaks. It is widely used in the inspection of tanks, pipelines, pressure vessels, and sealed components.

Indian Standards on Leak Testing:

i) **IS 9902 : 2004 – Recommended Practice for Leak Testing**
This standard provides recommended methods and guidelines for detecting gross and fine leaks in fabricated equipment using various leak testing techniques, like bubble, pressure drop, halogen, and helium mass spectrometry, with guidelines on test selection, setup, tracer gases, personnel qualification, and documentation.

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