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NONDESTRUCTIVE EVALUATION

TECHNIQUE GUIDE

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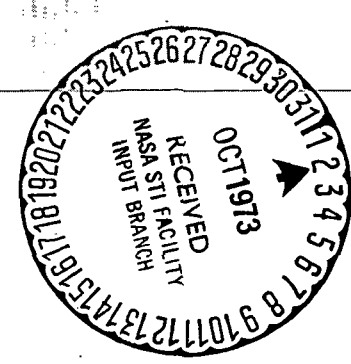

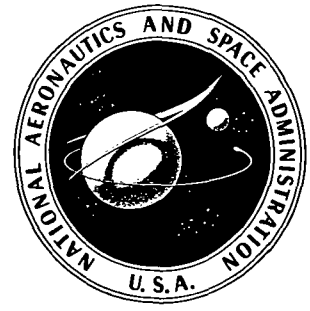

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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NONDESTRUCTIVE EVALUATION TECHNIQUE GUIDE

By Alex Vary

Lewis Research Center

Prepared by Lewis Research Center

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NONDESTRUCTIVE EVALUATION TECHNIQUE GUIDEBOOK

by Alex Vary

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SUMMARY

A total of 70 individual nondestructive evaluation (NDE) techniques are described, each in a standardized single-page format for quick reference. Information is presented in a manner that permits ease of comparison of the merits and limitations of each technique with respect to various NDE problems.

An NDE technique classification system is presented. It is based on the system that was adopted by the National Materials Advisory Board (NMAB). The classification system presented herein follows the NMAB system closely with the exception of additional categories that have been added to cover more advanced techniques presently in use.

The rationale of the technique description format used herein is explained. The format provides for a concise description of each technique, the physical principles involved, objectives of interrogation, example applications, limitations of each technique, a schematic illustration, and key reference material. Cross-index tabulations are also provided so that particular NDE problems can be referred to appropriate techniques.

INTRODUCTION

The intent of this publication is to serve as a guidebook for the application of nondestructive evaluation (NDE) techniques in materials science and technology. The objective is to provide a quick survey of currently available techniques particularly for those who are unfamiliar with the wide range covered by NDE.

Nondestructive evaluation is a branch of materials science that is concerned with all aspects of the uniformity, quality, and serviceability of materials and structures. The science of NDE involves all technology for the detection and measurement of significant properties, as well as defects, in items ranging from research specimens to finished hardware and products. By definition, nondestructive techniques are the means by which materials and structures may be interrogated without disruption or impairment

of their serviceability. Using NDE, internal properties or hidden flaws are revealed or inferred by appropriate techniques.

NDE is becoming an increasingly vital factor in the effective conduct of research, development, and manufacturing programs. Only with the appropriate use of NDE techniques can the benefits of advanced materials science and technology be fully realized. However, the basic information required for appreciating the broad scope of NDE is rather widely scattered in a multitude of publications and reports. The purpose of this report, therefore, is to present a concise compilation of NDE technique information in a format that briefly reviews the essential data for each technique currently in use.

The term technique as used herein refers to the body of specialized procedures, methods, and instruments associated with each specific NDE approach or area. There are usually numerous methods or modes of procedure associated with each technique. The objective herein is to identify, classify, and describe techniques without giving details on methods of application or procedures. The format adopted provides a resumé of each technique on a single page for quick reference.

MODE OF PRESENTATION

CLASSIFICATION OF TECHNIQUES

In its report (ref. 1), the National Materials Advisory Board (NMAB) Ad Hoc Committee on Nondestructive Evaluation adopted an NDE technique classification system that divided techniques into six major categories: visual, penetrating radiation, magnetic-electrical, mechanical vibrations, thermal, and chemical-electrochemical. A modified version of the NMAB classification system is presented in this report. Additional categories have been included herein in order to cover advanced techniques that are properly classed under NDE. The resultant classification system is described in table I. The first six categories involve basic physical processes that require the transfer of matter and/or energy with respect to the object being interrogated. The last two are auxiliary categories involving processes that provide for the transfer and accumulation of information. The techniques in the last two categories constitute the processing and, in essence, "nondestructive" evaluation of the raw signals and images produced by the more basic processes.

TECHNIQUE DESCRIPTION FORMAT

In order to describe each NDE technique on a single page, a concise method of exposition was adopted. Each page takes the form of a tabulation consisting of six block

TABLE I. - NONDESTRUCTIVE EVALUATION TECHNIQUE CATEGORIES

Categories	Objectives
BASIC CATEGORIES	
Mechanical-optical	Color; Crack; Dimensions; Film thickness; Gauging; Reflectivity; Strain distribution and magnitude; Surface finish; Surface flaws; Through cracks
Penetrating radiation	Bond separation; Cracks; Density; Density and chemistry variations; Elemental distribution; Foreign objects; Inclusions; Microporosity; Misalinement; Missing parts; Segregation; Shrinkage; Thickness; Voids
Electromagnetic-electronic	Alloy content; Anisotropy; Cavities; Cold work, Local strain, Hardness; Composition; Contamination; Corrosion; Cracks; Crack depth; Crystal structure; Electrical and thermal conductivity, Flakes; Heat treat; Hot tears; Inclusions; Ion concentrations; Laps; Lattice strain; Layer thickness; Moisture content; Polarization; Seams; Segregation; Shrinkage; State of cure; Tensile strength; Thickness; Unbond
Sonic-ultrasonic	Crack initiation and propagation; Cracks, Voids; Damping factor; Degree of cure; Degree of impregnation; Degree of sintering, Delaminations; Density; Dimensions; Elastic moduli; Grain size; Inclusions; Mechanical degradation; Misalinement; Porosity; Radiation degradation; Structure of composites; Surface stress; Tensile, shear and compressive strength; Unbonds; Wear
Thermal	Bonding; Composition; Emissivity; Heat contours; Plating thickness; Porosity; Reflectivity; Stress; Thermal conductivity; Thickness; Voids
Chemical-analytical	Alloy identification; Composition; Cracks; Elemental analysis and distribution; Grain size; Inclusions; Macrostructure; Porosity; Segregation; Surface flaws
AUXILIARY CATEGORIES	
Image generation	Dimensional variations; Dynamic performance; Flaw characterization and definition; Flaw distribution; Flaw propagation; Magnetic field configurations
Signal-image analysis	Data selection, processing, and presentation; Flaw mapping, correlation, and identification; Image enhancement; Separation of multiple variables; Signature analysis

headings: METHOD, PRINCIPLES, OBJECTIVES, APPLICATIONS, LIMITATIONS, and REFERENCES and an illustration. There are standard subheadings in each block to further organize the presentation of information. The ensuing paragraphs explain the mode of presentation and terminology used in the technique description format.

Technique

The technique name appears at the top of each form and is the one commonly used in

the literature. However, there are cases where different names are used for the same technique. For these cases, the alternative names are given in the REFERENCES block. Alternative technique names are cross referenced in the TECHNIQUE NAME INDEX.

Method

To further identify each technique, the METHOD block describes the key process and basic result. This is given in terms of the principal energy, matter, or information transfer process involved. The method description is usually divided into two brief sentences that concisely describe the technique and its basic results.

Principles

Each technique can be completely characterized in terms of five principal factors:

(1) Medium or energy source used to probe the interrogated object (e.g., X-rays, ultrasonic waves, and thermal radiation)

(2) Nature of the signal, image, and/or signature resulting from interaction with the object (e.g., attenuation of X-rays, and reflection of ultrasound)

(3) Method (or methods) of detecting or sensing the resultant signals (e.g., photoemulsion, piezoelectric crystal, and inductance coil)

(4) Method (or methods) of indicating and/or recording the signals (e.g., meter deflection, oscilloscope trace, and radiograph)

(5) Basis (or bases) for interpreting the results (e.g., direct or indirect indication, qualitative or quantitative, and pertinent dependencies)

One or two lines of descriptive terminology corresponding to each of these five factors is given in the PRINCIPLES block.

Objectives

The attributes for which test objects are scrutinized are listed as subheadings in the OBJECTIVES block. These attributes are

(1) Discontinuities and separations (cracks, voids, inclusions, delaminations, etc.)

(2) Structure or malstructure (crystalline structure, grain size, segregation, misalinement, etc.)

(3) Dimensions and metrology (thickness, diameter, gap size, flaw size, etc.)

(4) Physical and mechanical properties (reflectivity, conductivity, elastic modulus, sonic velocity, etc.)

TABLE II. - SPECIFIC OBJECTIVES OF NONDESTRUCTIVE EVALUATION TECHNIQUES

Main objectives	Specific objectives	Specific attributes measured or detected
Discontinuities and separations	Surface flaws	Roughness, scratches, gouges, crazing, pitting, inclusions, and imbedations
	Surface-connected flaws	Cracks, porosity, pinholes, laps, seams, folds, and inclusions
	Internal flaws	Cracks, separations, hot tears, cold shuts, shrinkage, voids, lack of fusion, pores, cavities, delaminations, debonds, poor bonds, inclusions, and segregations
Structure or mal-structure	Microstructure	Molecular structure; crystalline structure and/or strain; lattice structure, strain, dislocation, vacancy, and/or deformation
	Matrix structure	Grain structure, size, orientation, and phases; sinter and/or porosity; impregnation; filler and/or reinforcement distribution; anisotropy; inhomogeneity; and segregation
	Small structural flaws	Leaks (lack of seal/throughholes), poor fit, poor contact, loose parts and/or particles, and foreign objects
	Gross structural flaws	Assembly errors, misalinement, poor spacing or ordering, deformation, malformation, and missing parts
Dimensions and metrology	Displacement and/or position	Linear measurement, separation, gap size, flaw size, depth, location, and orientation
	Dimensional variations	Uneveness, nonuniformity, eccentricity, shape and contour, size and mass variations (of entire object or part)
	Thickness or density	Film, coating, layer, plating, wall, and sheet thickness; density or thickness variations
Physical and mechanical properties	Electrical properties	Resistivity, conductivity, dielectric constant, and dissipation factor
	Magnetic properties	Polarization, permeability, ferromagnetism, and cohesive force
	Thermal properties	Conductivity, thermal time constant, and thermoelectric potential
	Mechanical properties	Compressive, shear, and tensile strength (and moduli); Poisson's ratio; sonic velocity; hardness; temper; and embrittlement
	Surface properties	Color, reflectivity, refraction index, and emissivity
Chemical composition and analysis	Elemental analysis	Detection, identification, distribution, and/or profile
	Impurity concentrations	Contamination, depletion, doping, and diffusants
	Metallurgical content	Variation; alloy identification, verification, and sorting
	Physicochemical state	Moisture content, degree of cure, ion concentrations, and corrosion and reaction products
Stress and dynamic response	Stress, strain, and/or fatigue	Heat-treatment, annealing, and cold-work effects; residual stress and strain; and fatigue damage and life (residual)
	Mechanical damage	Wear, spalling, erosion, and friction effects
	Chemical damage	Corrosion, stress corrosion, and phase transformation
	Other damage	Radiation damage and high-frequency voltage breakdown
	Dynamic performance	Crack initiation and propagation, plastic deformation, creep, excessive motion, vibration, and damping
Signature analysis	Electromagnetic field	Potential, strength, and field distribution and pattern
	Thermal field	Isotherms, heat contours, temperatures, heat flow, temperature distribution, heat leaks, and hot spots
	Acoustic signature	Noise; vibration characteristics; frequency amplitude, harmonic analysis and/or spectrum; sonic and/or ultrasonic emissions
	Radioactive signature	Distribution and diffusion of isotopes and tracers
	Signal or image analysis	Image enhancement and quantization; pattern recognition; densitometry; signal classification, separation, and correlation; flaw identification, definition (size, shape), and distribution analysis; flaw mapping and display

(5) Composition and chemical analysis (alloy identification, impurities, elemental distributions, etc.)

(6) Stress and dynamic response (residual stress, crack growth, wear, vibration, etc.)

(7) Signature analysis (image content, frequency spectrum, field configuration, etc.)

Terms used in this block are further defined in table II with respect to specific objectives and specific attributes measured, detected, defined, and so forth.

Applications

The APPLICATIONS block lists practical uses of the technique. Information in this block is divided into three groups. Each is covered by two subheadings. The first group includes the materials and the particular forms and features of these materials to which the technique applies. The second group includes on-line process- and quality-control uses. The second also lists uses for monitoring and/or examining equipment during operation and maintenance. The third group lists representative components, structures, assemblies, and systems to which the technique has been applied.

Limitations

The LIMITATIONS block gives conditions required by the technique:

(1) Conditions to be met for technique application (access, physical contact, preparation, etc.)

(2) Requirements to adapt the probe or probe medium to the object examined

This block also identifies factors that

(1) Limit the detection and/or characterization of flaws, properties, and other attributes

(2) Limit the interpretation of signals and/or images generated

References

The REFERENCES block names reference material in which additional information is available. In some cases, adequate standard reference material is unavailable; and in those cases, supplemental auxiliary sources are cited. If available, standards, specifications, and bibliographical sources are also listed. Usually, however, the primary reference for each technique will contain a good bibliography. Related or synonymous terms for the technique are also listed in this block along with closely related techniques.

All source references in this block are abbreviated but are fully designated in the REFERENCES section (p. 78). A general supplemental BIBLIOGRAPHY section (p. 84) follows the REFERENCE section.

Illustrations

A schematic diagram illustrates a typical version of the basic process, configuration, and instrumentation involved in applying the technique.

NONDESTRUCTIVE EVALUATION TECHNIQUE CATALOG

The technique description catalog that follows is organized in accordance with the eight categories given in table I. The techniques that are described are grouped and presented in the order indicated in the table of contents. An index of flaw types and a tabulated guide to the use of NDE techniques is given at the end of this report (p. 86).

Although the catalog that comprises the body of this report is comprehensive, it is not exhaustive. Many instances exist wherein a number of techniques are so similar that they are combined under one representative heading to avoid unnecessary repetition. Nevertheless, there are a number of techniques that are similar and yet must be listed separately because they are conventionally recognized as separate techniques with unique methodologies (e.g., X- and gamma radiography). Moreover, there is necessarily considerable overlap between some "auxiliary" and "basic" techniques. However, the auxiliary techniques do constitute specialized branches that are distinct from the basic techniques upon which they may be based (e.g., fluoroscopy and film radiography against X- and gamma radiography per se). The prime criterion for selection of techniques described herein was that of presenting a comprehensive account of the many separate arts and technologies that currently constitute the field of NDE. Overall, the catalog covers all the principal NDE techniques currently in use.

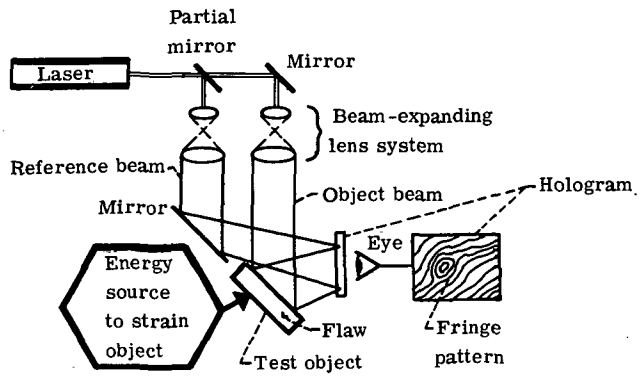
MECHANICAL-OPTICAL TECHNIQUES

Visual-Optical

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Direct visual and optically aided inspection is applied to object surfaces for indications of flaws and anomalies independently and in combination with other NDE techniques.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Visible light (ultraviolet light with fluorescent materials)
	NATURE OF SIGNAL AND/OR SIGNATURE	Reflected or transmitted photons
	DETECTION AND/OR SENSING METHOD	Eyes, optical aids, magnifiers, borescopes
	INDICATION AND/OR RECORDING METHOD	Visual image
	INTERPRETATION BASIS	Direct; used with other techniques for direct interpretation (e.g., liquid penetrants, filtered particle, magnetic particle)
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, voids, pores, inclusions
	STRUCTURE OR MALSTRUCTURE	Roughness, grain, film
	DIMENSIONS AND METROLOGY	(Mechanically aided) measurements
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Visible responses to stress
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Indefinite range of materials
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, layers, films, coatings, entire objects
	PROCESS CONTROL APPLICATIONS	On-line and off-line monitoring and control
	IN SITU AND DIAGNOSTIC APPLICATIONS	All forms of nondestructive inspection and testing
	EXAMPLE STRUCTURES AND COMPONENTS	Machined parts, internal surfaces; indefinite range of test objects, components assemblies, and systems
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Visual access
	PROBE AND OBJECT LIMITS	Specialized optical aids usually required
	SENSITIVITY AND/OR RESOLUTION	Various degrees of magnification
	INTERPRETATION LIMITS	Requires supplementation with other NDE techniques for flaw discrimination, detection, and measurement
	OTHER CONDITIONS AND LIMITS	Hazard with ultraviolet light
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 10, 11, and 12)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Borescopy, refractometry, diffractometry, interferometry, reflectometry, microscopy, telescopy, light radiometry, phase-contrast, and schlieren techniques

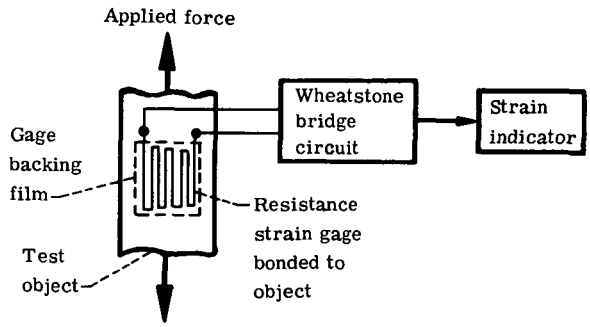
Holographic Interferometry

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Locates and measures surface microdisplacement and strain. Holographs made before and after stressing object are superposed to indicate subsurface and/or substrate strain or flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Laser light and mechanical, thermal, and/or acoustic stressing
	NATURE OF SIGNAL AND/OR SIGNATURE	Interference fringe pattern in superposed holograms
	DETECTION AND/OR SENSING METHOD	Holographic reconstruction and photoemulsion
	INDICATION AND/OR RECORDING METHOD	Viewing through reference holograph
	INTERPRETATION BASIS	Comparative or differential; becomes quantitative with fringe count or pattern calibration and/or standardization
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Delaminations, lack of bond, or poor bond
	STRUCTURE OR MALSTRUCTURE	Macrostructural variations
	DIMENSIONS AND METROLOGY	(Wall) thickness variations
	PHYSICAL AND MECHANICAL PROPERTIES	Load response of structures; strain
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Stress concentrations; vibration analysis
	SIGNATURE ANALYSIS	Load transfer or distribution characteristics
APPLICATIONS	MATERIALS TO WHICH APPLIED	All solids not plastically deformed by stress
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and exposed areas of complex objects
	PROCESS CONTROL APPLICATIONS	Inspection of welded, bonded, and fabricated parts
	IN SITU AND DIAGNOSTIC APPLICATIONS	Stress-strain patterns or parts and structures
	EXAMPLE STRUCTURES AND COMPONENTS	Aircraft and automotive tires, train wheels, airframes, wing panels, turbine blades and disks, nuclear fuel elements, honeycomb and composite structures
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Visual or optical access to test surface
	PROBE AND OBJECT LIMITS	Laser illumination must be adequate to field viewed.
	SENSITIVITY AND/OR RESOLUTION	Sensitive to half-wavelength surface displacements
	INTERPRETATION LIMITS	Ambient micromovements and noise patterns interfere.
	OTHER CONDITIONS AND LIMITS	Optics or object isolation required to eliminate extraneous or ambient displacements; potential hazard from laser beam
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 3 (ch. 15)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Holographic nondestructive testing (HNDT) and holointerferometry
	RELATED TECHNIQUES	Photoelastic coating, brittle coating, and strain gage



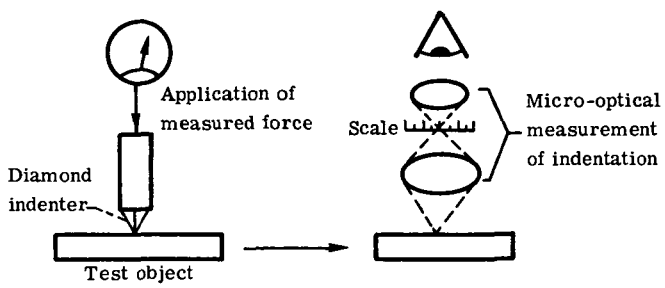
Strain Gage

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Electric resistance strain gage is bonded to surface of test object to indicate strain. Gage consists of fine wire or thin-foil grid layer sandwiched between layers of carrier material.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Electric current
	NATURE OF SIGNAL AND/OR SIGNATURE	Variation of gage resistance
	DETECTION AND/OR SENSING METHOD	Wheatstone bridge circuit
	INDICATION AND/OR RECORDING METHOD	Meter indication; potentiometer reading
	INTERPRETATION BASIS	Direct indication which is quantitative and depends on uniformity, standardization, and calibration of gages
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Microdisplacements, forces, torque, pressure, acceleration, and magnetostriction
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Stress-strain response and/or properties, creep, and crack growth
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and/or composites
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces
	PROCESS CONTROL APPLICATIONS	--------
	IN SITU AND DIAGNOSTIC APPLICATIONS	Tensile testing, stress analysis, and strain monitoring
	EXAMPLE STRUCTURES AND COMPONENTS	Operating turbines, engines, airframes, ship hulls, cranes, earth-moving equipment, and pressure vessels
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Clean and prepared surface and access to critical area
	PROBE AND OBJECT LIMITS	Application and orientation of gages critical
	SENSITIVITY AND/OR RESOLUTION	Measures strain to order of 1 micrometer per meter
	INTERPRETATION LIMITS	Affected by temperature, humidity, moisture, and slippage
	OTHER CONDITIONS AND LIMITS	Gage becomes permanently bonded to equipment.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 54)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Resistance gage
	RELATED TECHNIQUES	Photoelastic coating, brittle coating, holographic interferometry, and mechanical strain gage



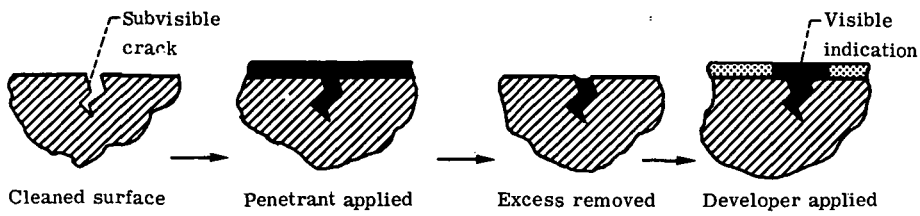
Microhardness

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Microindentation is made in test object surface. Microscopic measurement is made of indentation size to arrive at hardness value.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Specific diamond indenter applied with specific force
	NATURE OF SIGNAL AND/OR SIGNATURE	Indentation of specific geometric shape
	DETECTION AND/OR SENSING METHOD	Micro-optical comparator
	INDICATION AND/OR RECORDING METHOD	Visual and optical metrology
	INTERPRETATION BASIS	Relative (hardness values computed from formulas and read from charts); calibration standards required
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Hardness; tensile strength (qualitative)
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals
	FEATURES AND FORMS TO WHICH APPLIED	Surface and/or substrate; small specimens and/or localized spots
	PROCESS CONTROL APPLICATIONS	------
	IN SITU AND DIAGNOSTIC APPLICATIONS	------
	EXAMPLE STRUCTURES AND COMPONENTS	Metallurgical specimens
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to surface; surface grinding and/or polishing
	PROBE AND OBJECT LIMITS	Special fixturing to aline probe with surface
	SENSITIVITY AND/OR RESOLUTION	Sensitivity affected by load perpendicularity, vibrations, and surface finish
	INTERPRETATION LIMITS	Tensile strength values inexact
	OTHER CONDITIONS AND LIMITS	Limited to pointwise sampling
REFERENCES	PRIMARY SOURCE MATERIAL	----------
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-384-70
	RELATED TERMS	Hardness indentation; hardness test, Knoop and Vickers
	RELATED TECHNIQUES	----------



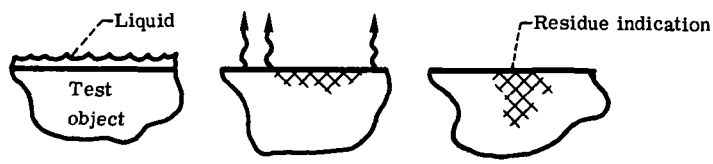
Liquid Penetrant

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Test surface is covered with penetrating liquid that seeks surface-connected cracks. Liquid in cracks bleeds out to stain powder-coating applied to surface after removal of excess liquid film from surface of test object.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Liquid medium containing dye or fluorescent substance
	NATURE OF SIGNAL AND/OR SIGNATURE	Capillary bleedout of liquid trapped in flaws
	DETECTION AND/OR SENSING METHOD	Localized staining of applied developer powder
	INDICATION AND/OR RECORDING METHOD	Direct visual observation for dye; black light for fluorescence
	INTERPRETATION BASIS	Direct indication (dependent on proper methods for application of penetrant and developer)
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, pinholes, laps, seams, coldshuts, leaks
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Fatigue cracking and grinding cracks
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	All nonporous, nonabsorbing materials
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, entire objects, and complex shapes
	PROCESS CONTROL APPLICATIONS	Control step in metal processing and/or joining
	IN SITU AND DIAGNOSTIC APPLICATIONS	Cracks formed during testing and equipment operation
	EXAMPLE STRUCTURES AND COMPONENTS	Weldments, joints, tubing, castings, and billets; fuel and liquid-oxygen tanks and vessels, aluminum parts, gas turbine disks and blades, engine mounts, and gears
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access required for surface decontamination and cleaning
	PROBE AND OBJECT LIMITS	Discontinuity must be surface-connected and open
	SENSITIVITY AND/OR RESOLUTION	Microcracks to order of 1-micrometer width
	INTERPRETATION LIMITS	False indications from shallow scratches and/or smearing
	OTHER CONDITIONS AND LIMITS	Porosity of surface may mask important indications. Discontinuity depth is not indicated. Ultraviolet-light hazard (with fluorescent penetrants); vapor hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 5 to 8)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	Reference 4, ASTM E-165-65, E-270-68
	RELATED TERMS	Dye penetrants and fluorescent penetrants
	RELATED TECHNIQUES	Filtered particle, electrified particle, magnetic particle, and radioactive gas penetrant



Volatile Liquid

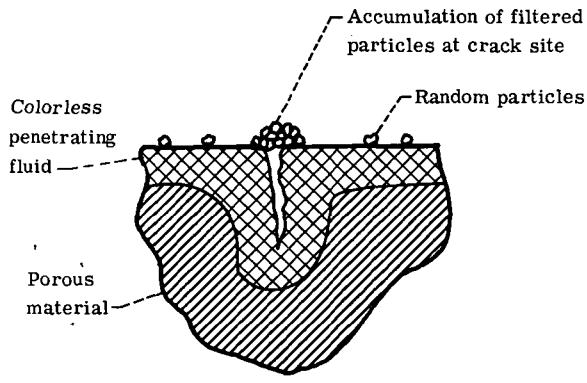
METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Thin layer of volatile liquid is applied to surface. The liquid evaporates uniformly except in areas that retain it as a result of porosity and/or cracks.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Volatile liquid (generally nondenatured ethanol)
	NATURE OF SIGNAL AND/OR SIGNATURE	Retention of liquid (slow-drying areas)
	DETECTION AND/OR SENSING METHOD	Visual: color and/or shading
	INDICATION AND/OR RECORDING METHOD	Visual
	INTERPRETATION BASIS	Direct or differential; based on evaporation time
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Porosity (variations)
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Porous solids
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces or surface-connected features
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Ceramics, graphite billets, rocket nozzles, solid rocket propellants, and ablative nose cones
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Surface access and clean lint-free surface required
	PROBE AND OBJECT LIMITS	Lint-free applicator and totally and uniformly wetted surface required
	SENSITIVITY AND/OR RESOLUTION	----------
	INTERPRETATION LIMITS	Background and/or color may reduce differentiation of wetted areas.
	OTHER CONDITIONS AND LIMITS	Requires heating to evaporate excess or residue; flammable liquid hazard
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 5
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Alcohol wipe
	RELATED TECHNIQUES	Filtered particle and electrified particle



Application | Penetration and evaporation | Retention

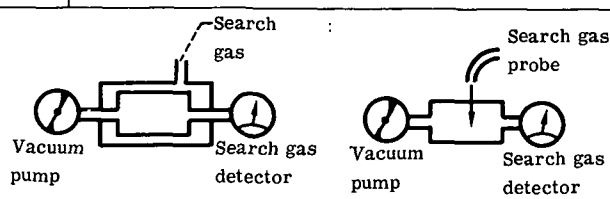
Filtered Particle

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Fluid-suspension of fine powder is sprayed on surface. Liquid is drawn into fine cracks leaving powder accumulation on surface at crack site.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Generally oil-base suspension of fine particles
	NATURE OF SIGNAL AND/OR SIGNATURE	Accumulation of particles at edge of crack
	DETECTION AND/OR SENSING METHOD	Visual examination for accumulations
	INDICATION AND/OR RECORDING METHOD	Dye or fluorescence; photography
	INTERPRETATION BASIS	Direct; particle size, shape, concentration, and penetrating power of fluid critical
OBJECTIVES	*DISCONTINUITIES AND SEPARATIONS*	Cracks and porosity
	STRUCTURE OR MALSTRUCTURE	Variations in absorption
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Porous solids (clay, carbon, powder metals, concrete, ceramics, cermets)
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces
	PROCESS CONTROL APPLICATIONS	--------
	IN SITU AND DIAGNOSTIC APPLICATIONS	--------
	EXAMPLE STRUCTURES AND COMPONENTS	Grinding wheels and insulators
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Clean and accessible surface required
	PROBE AND OBJECT LIMITS	Test-object pore size should be less than 100 mesh.
	SENSITIVITY AND/OR RESOLUTION	Sensitive to microcracks to order of 100 micrometers
	INTERPRETATION LIMITS	Depth of flaw not indicated
	OTHER CONDITIONS AND LIMITS	Residue removal required. Potential contamination. Cracks and/or pores must be open to surface. Skin irritants involved.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 9)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Fine particle (suspension)
	RELATED TECHNIQUES	Liquid penetrants and volatile liquid

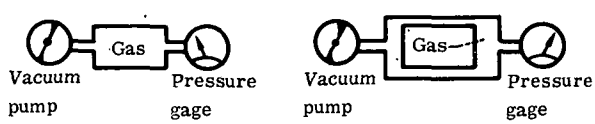


Leak Detection

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Exit of gas from or ingress of gas into sealed enclosure is induced. Enclosed or external search gas is used to locate and sense leaks and to estimate leak rate.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Search gas: helium, hydrogen, krypton-85
	NATURE OF SIGNAL AND/OR SIGNATURE	Leakage
	DETECTION AND/OR SENSING METHOD	Spectrometer, counter, and vacuum or pressure gage
	INDICATION AND/OR RECORDING METHOD	Meter indication; audible signal
	INTERPRETATION BASIS	Direct (standard reference leak required for quantitative indication)
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Through-holes and cracks
	STRUCTURE OR MALSTRUCTURE	Porosity and lack of seal
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and mixed, nonporous materials
	FEATURES AND FORMS TO WHICH APPLIED	Enclosures and seals
	PROCESS CONTROL APPLICATIONS	Quality control of envelopes and seals
	IN SITU AND DIAGNOSTIC APPLICATIONS	Vacuum leak check of experimental and operating equipment
	EXAMPLE STRUCTURES AND COMPONENTS	Weld, braze, and adhesive bonds; glass envelopes; vacuum chambers; elastomer and metal gasket seals; reactor fuel pins; liquid-metal containers and components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Direct access required to at least one side, indirect to the other
	PROBE AND OBJECT LIMITS	Special probe or sniffer; object enclosure usual
	SENSITIVITY AND/OR RESOLUTION	Sensitivity to order of 10^{-7} liter-nanobar per second
	INTERPRETATION LIMITS	----------
	OTHER CONDITIONS AND LIMITS	Location and size of leak are usually difficult to detect. Smeared metal or contaminants may plug leak passage. Radiation and other residual gas hazards are possible.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 6 (ch. 15)
	BIBLIOGRAPHICAL MATERIAL	Reference 7
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-425-71, E-427-71, E-432-71
	RELATED TERMS	Helium leak check and pressure check
	RELATED TECHNIQUES	Hydrostatic tests



Search gas detection methods

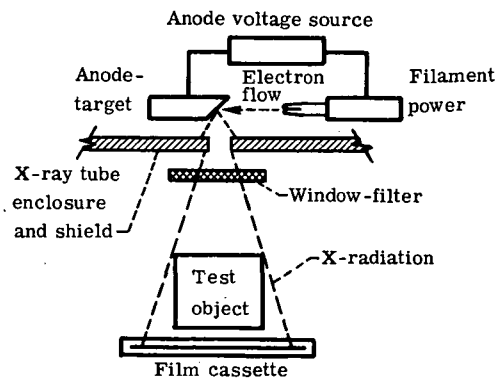


Pressure rise methods

PENETRATING RADIATION TECHNIQUES

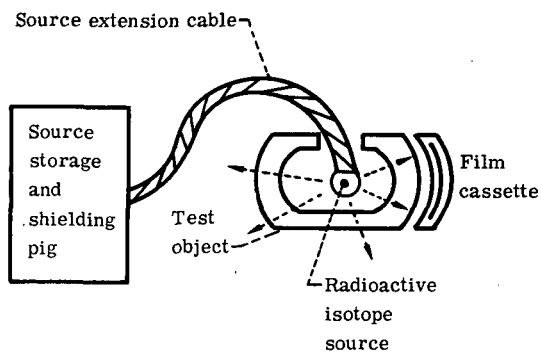
X-Radiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Penetrating radiation emitted by X-ray generator is imposed on test object. Radiation transmitted or attenuated by test object is used to image or detect internal structure and/or flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	X-rays in 10^{-13}- to 10^{-9}-meter wavelength range
	NATURE OF SIGNAL AND/OR SIGNATURE	Transmission or attenuation by object variables
	DETECTION AND/OR SENSING METHOD	Photoemulsion, fluoroscope, and/or radiometer
	INDICATION AND/OR RECORDING METHOD	Radiographic image; densitometry
	INTERPRETATION BASIS	Direct interpretation (standard penetrameters for image quality indication); control of contrast, resolution, and density critical
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, porosity, voids, and inclusions
	STRUCTURE OR MALSTRUCTURE	Internal malstructure, misassembly, or misalinement
	DIMENSIONS AND METROLOGY	Thickness, diameter, gap, and position
	PHYSICAL AND MECHANICAL PROPERTIES	Density variations
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Wear and corrosion
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, composites, and mixed materials
	FEATURES AND FORMS TO WHICH APPLIED	Entire objects or structures; wide range of shape and sizes
	PROCESS CONTROL APPLICATIONS	Joining and welding quality control
	IN SITU AND DIAGNOSTIC APPLICATIONS	Loose or stray parts and breakage in mechanisms
	EXAMPLE STRUCTURES AND COMPONENTS	Castings; welds; braze distribution; electronic assemblies; rocket propellant encasements; and aircraft, space, and automotive components and/or systems
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to opposite sides of test object required
	PROBE AND OBJECT LIMITS	Voltage, exposure time, and focal spot size critical
	SENSITIVITY AND/OR RESOLUTION	Density and thickness variations to order of 2 percent
	INTERPRETATION LIMITS	Sensitivity decreases with increasing thickness.
	OTHER CONDITIONS AND LIMITS	Cracks must be oriented parallel to beam. Radiation hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 17, 21, 24, and 25)
	BIBLIOGRAPHICAL MATERIAL	Reference 8
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-142-68; E-94-68
	RELATED TERMS	Film radiography
	RELATED TECHNIQUES	Gamma radiography, neutron radiography, autoradiography, and microradiography



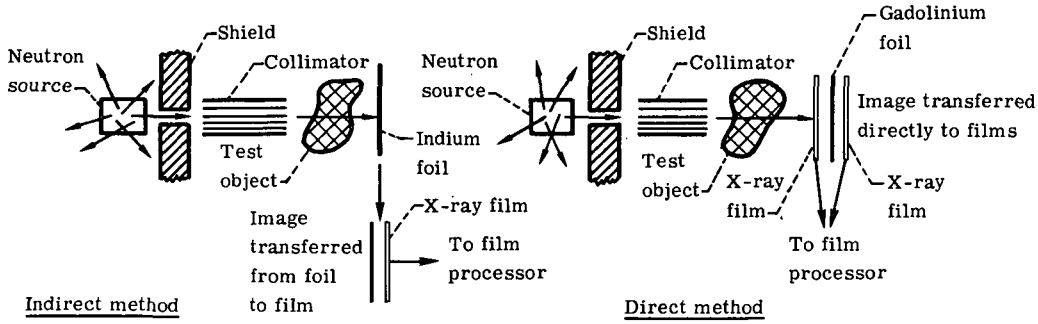
Gamma Radiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Penetrating radiation emitted by isotope source is imposed on test object. Radiation transmitted or attenuated by test object is used to image or detect internal structure and/or flaws in thick cross sections of dense materials.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Gamma radiation in 10^{-13}- to 10^{-9}-meter wavelength range
	NATURE OF SIGNAL AND/OR SIGNATURE	Transmission or attenuation by object variables
	DETECTION AND/OR SENSING METHOD	Photoemulsion and/or radiometer
	INDICATION AND/OR RECORDING METHOD	Radiographic image; densitometry
	INTERPRETATION BASIS	Direct interpretation (standard penetrameters for image quality indication); control of contrast, resolution, and density critical
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, porosity, voids, and inclusions
	STRUCTURE OR MALSTRUCTURE	Internal malstructure or malformation
	DIMENSIONS AND METROLOGY	Dimensional variations and anomalies, thickness, and gaps
	PHYSICAL AND MECHANICAL PROPERTIES	Density variations
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	Panoramic imaging
APPLICATIONS	MATERIALS TO WHICH APPLIED	Usually applied to dense or thick metallic materials
	FEATURES AND FORMS TO WHICH APPLIED	Entire objects or structures; range of shapes and sizes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Castings, thick or large components, and especially configurations not accessible to X-ray generators
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Often requires fitting source inside complex parts
	PROBE AND OBJECT LIMITS	Special mechanism for remote extension of source to part
	SENSITIVITY AND/OR RESOLUTION	Density or thickness variations to order of 2 percent
	INTERPRETATION LIMITS	Sensitivity usually less than with X-rays
	OTHER CONDITIONS AND LIMITS	Cracks must be oriented parallel to rays. Source energy uncontrollable and decays with time. Radiation hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 15)
	BIBLIOGRAPHICAL MATERIAL	Reference 8
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-280-68, E-94-68
	RELATED TERMS	----------
	RELATED TECHNIQUES	X-radiography and neutron radiography



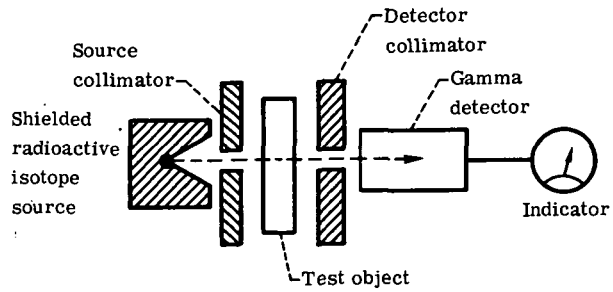
Neutron Radiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Neutron beam from reactor, accelerator, or isotope source is imposed on test object. Neutrons transmitted or attenuated by test object are used to image or detect internal structure and/or flaws that are poorly revealed by X- and gamma radiation.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Thermal or epithermal neutron beam
	NATURE OF SIGNAL AND/OR SIGNATURE	Transmission or attenuation by object variables
	DETECTION AND/OR SENSING METHOD	Activation of metallic foil and indirect transfer to photoemulsion
	INDICATION AND/OR RECORDING METHOD	Radiographic image; densitometry
	INTERPRETATION BASIS	Direct interpretation (standard penetrameters for image quality indication); control of contrast resolution and density critical
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Voids, porosity, inclusions, and cracks
	STRUCTURE OR MALSTRUCTURE	Internal malstructure, anomalies, and/or misalinement
	DIMENSIONS AND METROLOGY	Thickness, diameters, and gaps
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Contamination; element and/or isotope distribution and/or identification
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, composites, and mixed materials
	FEATURES AND FORMS TO WHICH APPLIED	Entire objects or structures; range of shape and sizes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Pyrotechnic devices, resins, plastics, organic substances, honeycomb structures, integrated microcircuits, nuclear fuel elements, radioactive materials, high-density metals, materials containing hydrogen
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to interpose object between source and detectors
	PROBE AND OBJECT LIMITS	Collimation, filtering, and moderation of neutron beam
	SENSITIVITY AND/OR RESOLUTION	Density or thickness variations to order of 2 percent
	INTERPRETATION LIMITS	Sensitivity decreases with increasing thickness.
	OTHER CONDITIONS AND LIMITS	Cracks must be oriented parallel to beam. Image quality varies with neutron source. Radiation hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 9
	BIBLIOGRAPHICAL MATERIAL	Reference 8
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Neutrography
	RELATED TECHNIQUES	X-radiography and gamma radiography



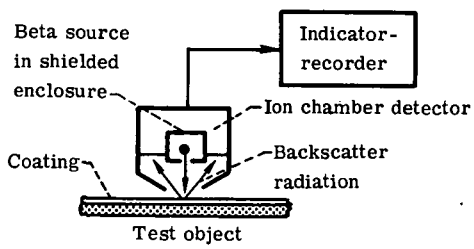
Penetrating Radiometry

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Penetrating radiation is directed through selected small areas of test object and radiation intensity emerging on opposite side is measured. This provides a more precise measure of attenuation than X- or gamma-radiography.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	X, gamma, or beta-particle radiation
	NATURE OF SIGNAL AND/OR SIGNATURE	Attenuation of transmitted radiation
	DETECTION AND/OR SENSING METHOD	Crystal and/or scintillation detector
	INDICATION AND/OR RECORDING METHOD	Meter deflection; coordinate plot
	INTERPRETATION BASIS	Comparative and differential; quantitative with standards of comparison
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Voids, inclusions, and porosity
	STRUCTURE OR MALSTRUCTURE	-------
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Density
	COMPOSITION AND CHEMICAL ANALYSES	-------
	STRESS AND DYNAMIC RESPONSES	-------
	SIGNATURE ANALYSIS	-------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, composites, and mixed materials
	FEATURES AND FORMS TO WHICH APPLIED	Platelike, rodlike, or uniform shapes; coatings; and foils
	PROCESS CONTROL APPLICATIONS	In-line monitoring of metal and other processing
	IN SITU AND DIAGNOSTIC APPLICATIONS	Resin-to-fiber ratio evaluation in laminar composites
	EXAMPLE STRUCTURES AND COMPONENTS	Sheet, plate, strip, tube, plated parts, and reactor fuel rods and/or plates
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to interpose object between source and detector
	PROBE AND OBJECT LIMITS	Beam size and alinement critical
	SENSITIVITY AND/OR RESOLUTION	Transmission variations to order of 0.2 percent
	INTERPRETATION LIMITS	Nature of flaw may be ambiguous as a result mixed effects.
	OTHER CONDITIONS AND LIMITS	Beta radiation applies to ultrathin sheet and coatings. Radiation hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 18)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Isotope gaging, gamma radiometry, X-radiometry, X-ray thickness gage, radiosotope thickness
	RELATED TECHNIQUES	----------



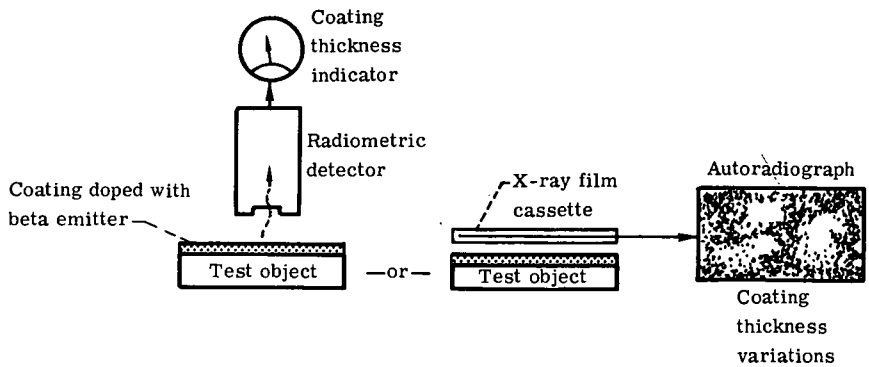
Backscatter Radiometry

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Backscatter, gamma, or X-rays are impinged on a surface layer, and a detector measures backscatter rate and intensity as an indication of fine variations in coating and/or surface layer thickness and elemental distributions.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Beta particles, soft gamma, or X-rays from small source
	NATURE OF SIGNAL AND/OR SIGNATURE	Backscattered betas or radiation
	DETECTION AND/OR SENSING METHOD	Counter; radiometer
	INDICATION AND/OR RECORDING METHOD	Meter deflection; coordinate plot
	INTERPRETATION BASIS	Comparative or differential; becomes quantitative with the use of reference standards and/or calibration
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	---
	STRUCTURE OR MALSTRUCTURE	---
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	---
	COMPOSITION AND CHEMICAL ANALYSES	Elemental distributions and analyses
	STRESS AND DYNAMIC RESPONSES	---
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Coatings, layers, films, substrates, and surfaces
	PROCESS CONTROL APPLICATIONS	Thickness monitoring
	IN SITU AND DIAGNOSTIC APPLICATIONS	---
	EXAMPLE STRUCTURES AND COMPONENTS	Paint, plastic coatings, and composite laminates; identification and analysis of alloys, solutions, and ores
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Close proximity to surface required
	PROBE AND OBJECT LIMITS	Special miniaturized probes required for adequate spatial resolution
	SENSITIVITY AND/OR RESOLUTION	Thickness variations to order of 10 micrometers
	INTERPRETATION LIMITS	Ambiguous response from mixed variables
	OTHER CONDITIONS AND LIMITS	Low-energy radiation
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 6 (ch. 14)
	BIBLIOGRAPHICAL MATERIAL	References 10 and 11
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	Beta-backscatter and gamma-backscatter
	RELATED TECHNIQUES	Penetrating radiometry and Mössbauer analysis



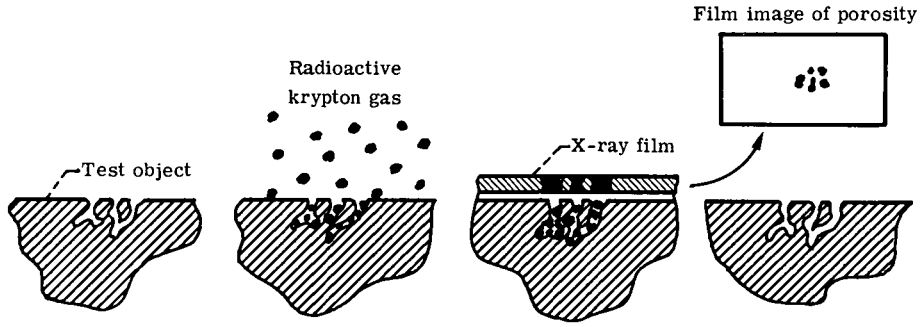
Autoradiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Isotopic radiation emitted by test object is utilized. Radiometry or radiography detects and measures the distribution and quantity of radioactive species.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Radioisotopes incorporated in test object or naturally radioactive materials
	NATURE OF SIGNAL AND/OR SIGNATURE	Beta or gamma radiation
	DETECTION AND/OR SENSING METHOD	Crystal and/or scintillation detector and/or counter; photoemulsion
	INDICATION AND/OR RECORDING METHOD	Meter deflection, radiograph, and/or coordinate plot
	INTERPRETATION BASIS	Differential; quanitative with calibration
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	---
	STRUCTURE OR MALSTRUCTURE	Continuity and homogeneity
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	---
	COMPOSITION AND CHEMICAL ANALYSES	Element and isotope distribution and identification
	STRESS AND DYNAMIC RESPONSES	Stress and/or thermal effects; wear, erosion, and/or abrasion; chemical reaction rates
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and/or substrates, and coatings
	PROCESS CONTROL APPLICATIONS	Coating application, thickness, and/or continuity
	IN SITU AND DIAGNOSTIC APPLICATIONS	Maintenance evaluation of protective surfaces
	EXAMPLE STRUCTURES AND COMPONENTS	Silicide coatings, nuclear fuel elements, geological specimens, minerals, and ores
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Close access to surface
	PROBE AND OBJECT LIMITS	Incorporation of radioisotopes for labeling
	SENSITIVITY AND/OR RESOLUTION	Beta penetration limited to order of 100 micrometers
	INTERPRETATION LIMITS	Analytical sensitivity depends on background radiation.
	OTHER CONDITIONS AND LIMITS	Potential hazard in radioactive dust from surface
REFERENCES	PRIMARY SOURCE MATERIAL	References 12 and 13
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	---
	RELATED TECHNIQUES	Radioactive labeling and tracer autoradiography



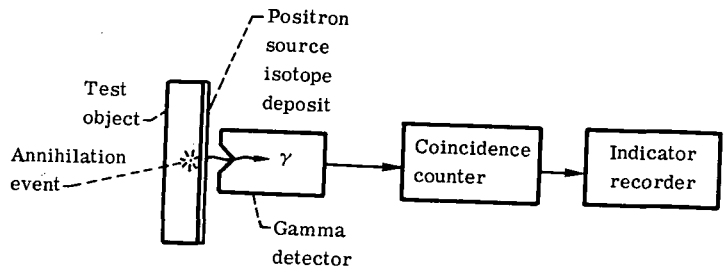
Radioactive Gas Penetrant

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Radioactive gas penetrates surface-connected discontinuities. Beta radiation from gas adsorbed in cracks and pores is detected and indicates distribution and size of flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Radioactive gas molecules, usually krypton-85
	NATURE OF SIGNAL AND/OR SIGNATURE	Localized beta and gamma emission
	DETECTION AND/OR SENSING METHOD	Crystal detector; photoemulsion
	INDICATION AND/OR RECORDING METHOD	Meter deflection; radiograph
	INTERPRETATION BASIS	Direct indication; dependent on proper controlled procedures for material preparation and penetration
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks and pores
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Oxidation and corrosion
	STRESS AND DYNAMIC RESPONSES	Friction, wear, erosion, and abrasion effects
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and nonporous or nonabsorbent solids
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Metallurgical specimens, engine components, bearings, and turbine disks and blades
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Surface cleaning and penetration method critical
	PROBE AND OBJECT LIMITS	Flexible photoemulsion base or spray coating
	SENSITIVITY AND/OR RESOLUTION	Crack width to order of 0.01 micrometer
	INTERPRETATION LIMITS	Extremely sensitive to spurious mars and scratches
	OTHER CONDITIONS AND LIMITS	Flaw depth must be inferred. Radiation hazard, requires gas recovery system.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 14
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Kryptonation
	RELATED TECHNIQUES	Autoradiography



Positron Annihilation

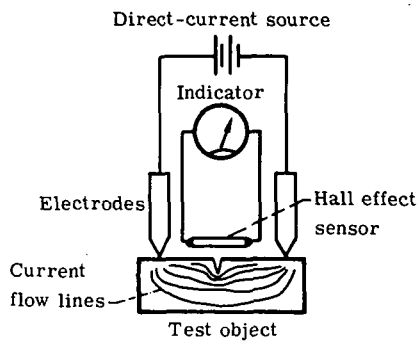
METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Beam of positrons penetrates specimen subsurface. Gamma photons resulting from positron annihilation are more copiously emitted at loci with microstrain or electron concentrations.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Positrons from isotope deposit on specimen surface
	NATURE OF SIGNAL AND/OR SIGNATURE	Count of positron annihilation events
	DETECTION AND/OR SENSING METHOD	Gamma detector and coincidence counter
	INDICATION AND/OR RECORDING METHOD	Counter display
	INTERPRETATION BASIS	Differential analysis based on event rate intervals between e^+ and γ emissions
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Lattice dislocations and/or vacancies
	STRUCTURE OR MALSTRUCTURE	Plastic strain loci
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Overaging or reversion, incipient cracking, fatigue, localized work-harding, and annealing
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals (such as aluminum and copper alloys)
	FEATURES AND FORMS TO WHICH APPLIED	Subsurfaces and substrates
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Experimental specimens
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Close proximity to surface
	PROBE AND OBJECT LIMITS	Deposition of isotope or source on surface required
	SENSITIVITY AND/OR RESOLUTION	Subsurface penetration range of order of 1 millimeter
	INTERPRETATION LIMITS	Nanosecond time intervals are significant.
	OTHER CONDITIONS AND LIMITS	Technique is experimental. Radiation hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 15
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	----------



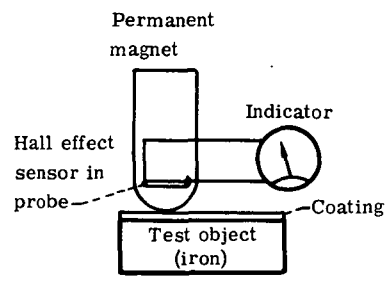
ELECTROMAGNETIC-ELECTRONIC TECHNIQUES

Static Magnetic Field

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Magnetic field is imposed on test object. Field permeates and magnetizes object and test zone and probe scans and detects field perturbations that are characteristic of surface and/or subsurface flaws and anomalies.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Static magnetic field induced or superposed on object
	NATURE OF SIGNAL AND/OR SIGNATURE	Field gradient and normal or tangential perturbations
	DETECTION AND/OR SENSING METHOD	Rotating or oscillating coil; Hall or Foerster probe
	INDICATION AND/OR RECORDING METHOD	Meter deflection; coordinate plot and field map
	INTERPRETATION BASIS	Comparative or differential; requires standard defects for comparison
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, inclusions, gouges, scratches, holes, and pores
	STRUCTURE OR MALSTRUCTURE	Magnetic anisotropy
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Coercive force, magnetic permeability, hardness
	COMPOSITION AND CHEMICAL ANALYSES	Compositional variations
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	Magnetic field strength, signature, and characteristics
APPLICATIONS	MATERIALS TO WHICH APPLIED	Ferromagnetic and permeable metals
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates; uniform and regular shapes
	PROCESS CONTROL APPLICATIONS	Feedback sorting
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Nonmagnetic coating thickness, depth of case hardening, analysis of carbon content in steels, bearing raceways, gear teeth
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Very near proximity of probe to surface
	PROBE AND OBJECT LIMITS	Specialized probes usual for various measurements
	SENSITIVITY AND/OR RESOLUTION	Cracks to order of 0.03 millimeters
	INTERPRETATION LIMITS	Ambiguities arise because of edge and/or lift-off effects.
	OTHER CONDITIONS AND LIMITS	Access to both sides for some thickness measuring; does not discriminate among types of flaws
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 33 and 34)
	BIBLIOGRAPHICAL MATERIAL	References 16 and 17
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Magnetic field perturbation and magnetic field test
	RELATED TECHNIQUES	Magnetic particle and eddy current



Electrically produced field

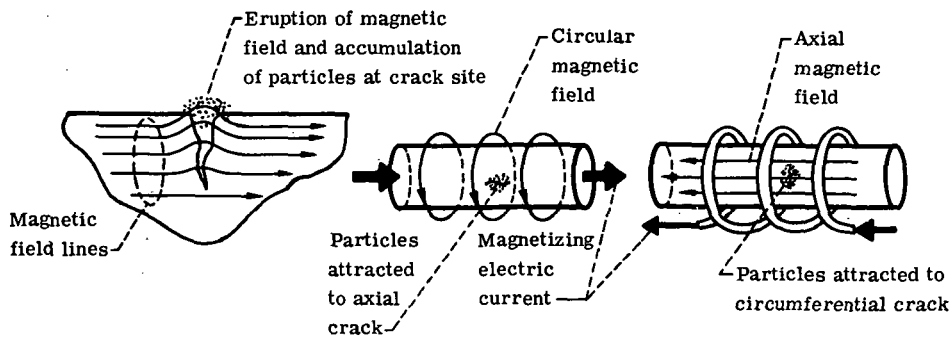


Magnetically produced field

Magnetic Particle

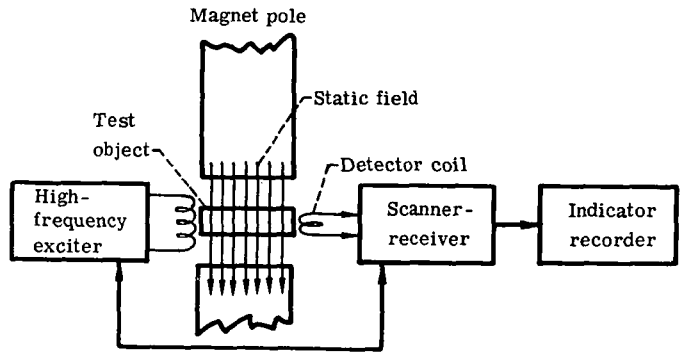
METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Test object or part is magnetized. Magnetic powder applied to surface accumulates over regions where magnetic field erupts or emerges as a result of surface or subsurface flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Magnetizing current or field imposed on part
	NATURE OF SIGNAL AND/OR SIGNATURE	Field distortion or leakage at surface
	DETECTION AND/OR SENSING METHOD	Accumulation and pattern of magnetic powder clusters; pattern in magnetic tape[a]
	INDICATION AND/OR RECORDING METHOD	Visual, photography, and magnetic tape and/or rubber
	INTERPRETATION BASIS	Direct indication, depends on direction and strength of magnetic field and on powder and vehicle control
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, seams, pores, and inclusions
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Permeability variations
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Ferromagnetic materials
	FEATURES AND FORMS TO WHICH APPLIED	Surface and substrate; regular and uniform shapes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Bars, forgings, weldments, extrusions, fasteners, engine components, shafts, and gears
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Requires clean and relatively smooth surface
	PROBE AND OBJECT LIMITS	Fixturing required to hold and magnetize part
	SENSITIVITY AND/OR RESOLUTION	Cracks to order of 0.5-millimeter major dimension
	INTERPRETATION LIMITS	Field alinement and strength critical
	OTHER CONDITIONS AND LIMITS	Followup metal removal may be required. Part demagnetization may be problematic. Removal of powder and vehicle required.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 30 to 32)
	BIBLIOGRAPHICAL MATERIAL	Reference 18
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-109-63(71), E-138-63(71), E-269-68
	RELATED TERMS	Magnetic tape and magnetic rubber
	RELATED TECHNIQUES	Magnetic field perturbation and eddy current

[a]Also field set into room-temperature vulcanizing magnetic silicone rubber replication of magnetized part.



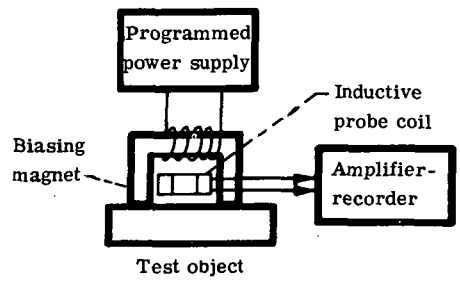
Nuclear Magnetic Resonance

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Specimen is immersed in static magnetic field. Radiofrequency excitation is applied to specimen to induce nuclear spin resonances characteristic of lattice structure and local strain.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Radiofrequency excitation in static magnetic field
	NATURE OF SIGNAL AND/OR SIGNATURE	Absorption of energy by nuclear spin effects
	DETECTION AND/OR SENSING METHOD	Resonance and spin-echo pickup coil
	INDICATION AND/OR RECORDING METHOD	Spectrograph and oscillope display
	INTERPRETATION BASIS	Spectrographic (requires library of spectra)
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	Lattice environment (of element and isotope)
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Dopants, impurities, and composition
	STRESS AND DYNAMIC RESPONSES	Local and/or residual strain
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals (including semiconductors), liquids, and gases
	FEATURES AND FORMS TO WHICH APPLIED	Substrates, specimens or samples, particles and powder
	PROCESS CONTROL APPLICATIONS	Experimental specimens
	IN SITU AND DIAGNOSTIC APPLICATIONS	Phase study of melts
	EXAMPLE STRUCTURES AND COMPONENTS	Metal powder, moisture content (of paper), and germanium or silicon semiconductors
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Close proximity to surface; specimen containment
	PROBE AND OBJECT LIMITS	Excitation and probe coils must adapt to part or specimen
	SENSITIVITY AND/OR RESOLUTION	Detects to order of 10 percent of elements present
	INTERPRETATION LIMITS	Restricted to surface because of "skin-effect"
	OTHER CONDITIONS AND LIMITS	Material must contain nuclei with magnetic moments.
REFERENCES	PRIMARY SOURCE MATERIAL	References 19 and 20
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Electron paramagnetic resonance and nuclear quadrupole resonance



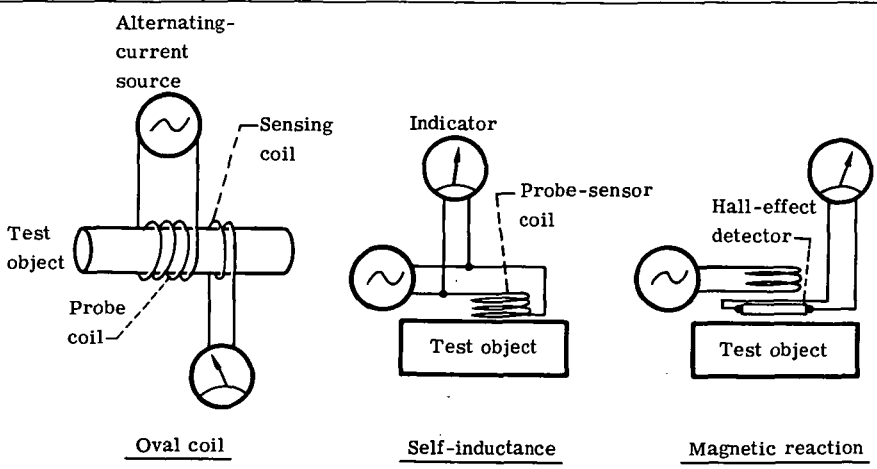
Barkhausen Effect

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Ferromagnetic material is magnetized by external field, and Barkhausen noise indicates state of residual stress. Indications derive from small abrupt increments in magnetization.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Increasing or decreasing magnetizing field
	NATURE OF SIGNAL AND/OR SIGNATURE	Abrupt magnetization increments; Barkhausen noise
	DETECTION AND/OR SENSING METHOD	Inductive loop or coil; Hall probe
	INDICATION AND/OR RECORDING METHOD	Oscilloscope display; coordinate plot
	INTERPRETATION BASIS	Comparative or differential analysis; requires catalog of Barkhausen signatures for different matrixes and substrates
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Inclusions
	STRUCTURE OR MALSTRUCTURE	Grain size, orientation, and inhomogeneities
	DIMENSIONS AND METROLOGY	---
	PHYSICAL AND MECHANICAL PROPERTIES	---
	COMPOSITION AND CHEMICAL ANALYSES	---
	STRESS AND DYNAMIC RESPONSES	Magnitude and direction of applied and residual stresses
	SIGNATURE ANALYSIS	Stress fields accompanying plastic deformation
APPLICATIONS	MATERIALS TO WHICH APPLIED	Ferromagnetic materials
	FEATURES AND FORMS TO WHICH APPLIED	Subsurfaces and substrates; specimens and samples
	PROCESS CONTROL APPLICATIONS	---
	IN SITU AND DIAGNOSTIC APPLICATIONS	Diagnosing stress fields and states
	EXAMPLE STRUCTURES AND COMPONENTS	Compressor and turbine disks and blades, bearings, and power transmission components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to surface required; contact not necessary
	PROBE AND OBJECT LIMITS	Probe and magnetizer must accommodate part.
	SENSITIVITY AND/OR RESOLUTION	Changes of the order of magnetic domain size
	INTERPRETATION LIMITS	Ambient noise and/or fields may mask indications.
	OTHER CONDITIONS AND LIMITS	Limited to flaw location and ferromagnetic inclusions
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 16
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	Barkhausen noise
	RELATED TECHNIQUES	---



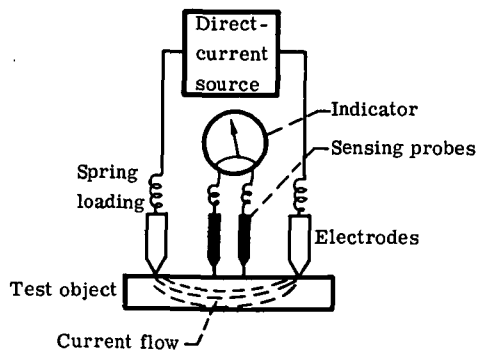
Eddy Current

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Localized alternating-current loop (eddy) is induced in test object. Inductive reactance of probe to magnetic field of induced current indicates subsurface flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Localized induced current of 200-Hz to 2-MHz range
	NATURE OF SIGNAL AND/OR SIGNATURE	Perturbation of induced current and hence induced magnetic field
	DETECTION AND/OR SENSING METHOD	Inductance coil; Hall probe
	INDICATION AND/OR RECORDING METHOD	Meter deflection; oscilloscope trace
	INTERPRETATION BASIS	Differential or comparative; reference standard required for each type of flaw
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, seams, pits, and inclusions
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	(Wall) thickness and coating thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Conductivity and permeability
	COMPOSITION AND CHEMICAL ANALYSES	Composition variations
	STRESS AND DYNAMIC RESPONSES	Heat-treatment effects
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, alloys, and electroconductors
	FEATURES AND FORMS TO WHICH APPLIED	Subsurfaces and substrates; regular and uniform shapes
	PROCESS CONTROL APPLICATIONS	Feedback control for sorting materials and parts
	IN SITU AND DIAGNOSTIC APPLICATIONS	In-situ diagnosing of rotating components
	EXAMPLE STRUCTURES AND COMPONENTS	Tube, wire, ball bearings, nonmetal coatings, train rails and wheels, airframe components, turbine blades and disks, and automotive transmission shafts
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	No contact but close proximity of probe to surface
	PROBE AND OBJECT LIMITS	Probe usually tailored to accommodate and fit around item
	SENSITIVITY AND/OR RESOLUTION	Cracks to order of 0.2-millimeter length
	INTERPRETATION LIMITS	False indications possible because of mixed variables, edge effects, and lift-off (clearance) effects
	OTHER CONDITIONS AND LIMITS	Low penetration (limited to thin walls or near-surface flaws)
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 35 to 42)
	BIBLIOGRAPHICAL MATERIAL	Reference 7
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-309-71, E-243-67T, E-246-71, E-215-67, E-268-68
	RELATED TERMS	Magnetic reaction analysis and phase-sensitive eddy current
	RELATED TECHNIQUES	Static magnetic field, magnetic particle, and electric current



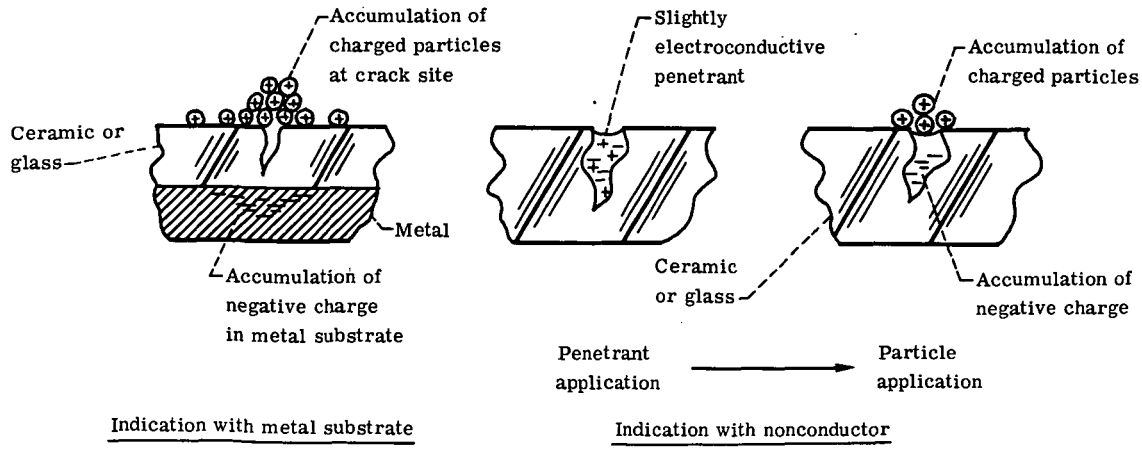
Electric Current

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Current is flowed through part or zone under test. Current strength or density between electrode pair touching surface is affected by inhomogeneities and discontinuities.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Current between pair of surface contacts or probes
	NATURE OF SIGNAL AND/OR SIGNATURE	Voltage drop and external magnetic field perturbation
	DETECTION AND/OR SENSING METHOD	Potential probes, Hall probe, or induction coil
	INDICATION AND/OR RECORDING METHOD	Potentiometer indication; oscillograph
	INTERPRETATION BASIS	Comparative; requires standard flaws and calibration curves
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks and inclusions
	STRUCTURE OR MALSTRUCTURE	Segregations and grain orientation
	DIMENSIONS AND METROLOGY	Thickness variations
	PHYSICAL AND MECHANICAL PROPERTIES	Resistivity, conductivity, and stress or cold-work
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Corrosion, erosion, wear effects, fatigue damage, and crack propagation
	SIGNATURE ANALYSIS	
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metallic materials and electroconductors
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates; uniform, regular areas and shapes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	Railroad track scanning
	EXAMPLE STRUCTURES AND COMPONENTS	Bars, plate, rails, fastenings, and joints; pressure vessels, tanks, and hulls
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Good surface contact required
	PROBE AND OBJECT LIMITS	Electrode or probe spacing and contact critical
	SENSITIVITY AND/OR RESOLUTION	Can indicate (relative) depth of cracks
	INTERPRETATION LIMITS	Dependent upon shape and orientation of discontinuity
	OTHER CONDITIONS AND LIMITS	Edge-effects and contamination of surface limit utility; may mar surface
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 35)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Electric current injection
	RELATED TECHNIQUES	Static magnetic field and eddy current



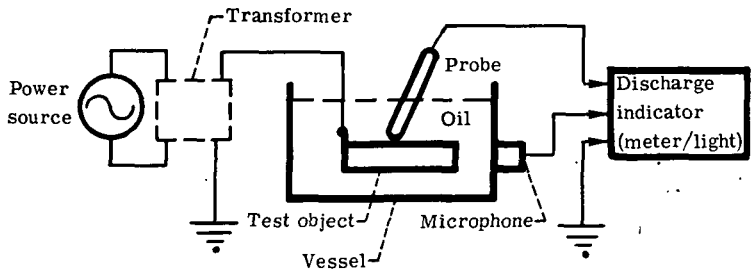
Electrified Particle

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Electrified powder is sprayed on surface. Attracted by electrostatic charge distribution at surface cracks, electrified powder accumulates at edge of cracks.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Spray of triboelectrified powder (usually $CaCO_3$)
	NATURE OF SIGNAL AND/OR SIGNATURE	Accumulation of particles drawn to edge of crack
	DETECTION AND/OR SENSING METHOD	Visual examination for accumulations
	INDICATION AND/OR RECORDING METHOD	Side illumination and photographic recording
	INTERPRETATION BASIS	Direct indication; dependent on particle size and shape, gas (air) supply, and humidity control
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, pinholes, and crazing
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Crack growth characteristics
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Electrically nonconducting materials
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and coatings
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Porcelain enamel; enamel, plastic, and paint coatings; glass-to-metal seals; metal-backed dielectric materials; brittle coating stress cracks; ceramics
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Surface must be carefully cleaned and dried.
	PROBE AND OBJECT LIMITS	Flaw must be surface connected
	SENSITIVITY AND/OR RESOLUTION	Cracks to order of 0.1 micrometer wide
	INTERPRETATION LIMITS	False indications caused by high humidity, moisture streaks, lint, and improper cleaning and/or drying
	OTHER CONDITIONS AND LIMITS	Poor resolution on thin coatings; high-voltage discharge but slight shock
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 28 and 29)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Triboelectrified powder
	RELATED TECHNIQUES	Filtered particles



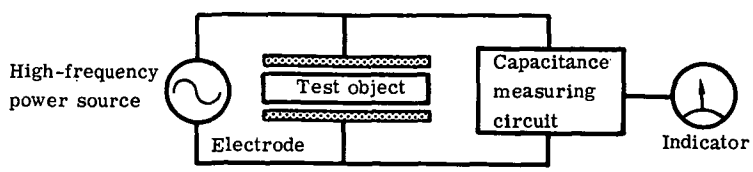
Corona Discharge

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Field of intense ionization and discharge is produced by high-voltage probe touching part near flaw. Gas and vapor trapped in cracks and voids is ionized and detected.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Applied voltage field (usually alternating voltage)
	NATURE OF SIGNAL AND/OR SIGNATURE	Current pulse, radiofrequency radiation and/or static, audible sound, and sparks
	DETECTION AND/OR SENSING METHOD	Visual, microphone, and electrometer
	INDICATION AND/OR RECORDING METHOD	Meter deflection, neon flash, and audio signal
	INTERPRETATION BASIS	Direct; can be calibrated to indicate gas volume contained in discontinuity
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, voids, debonds, and delaminations
	STRUCTURE OR MALSTRUCTURE	---
	DIMENSIONS AND METROLOGY	---
	PHYSICAL AND MECHANICAL PROPERTIES	---
	COMPOSITION AND CHEMICAL ANALYSES	---
	STRESS AND DYNAMIC RESPONSES	---
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Nonmetallic and dielectric materials
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates; range of shapes and sizes
	PROCESS CONTROL APPLICATIONS	Process residue and/or contamination
	IN SITU AND DIAGNOSTIC APPLICATIONS	---
	EXAMPLE STRUCTURES AND COMPONENTS	Solvent or liquid penetrant contamination of parts. Electrical wiring, reinforced plastics, filament-wound structures, and laminated structures.
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to surface required
	PROBE AND OBJECT LIMITS	Polished probe and grounding fixture for part needed; probe shape critical
	SENSITIVITY AND/OR RESOLUTION	Rough indication of crack or void size
	INTERPRETATION LIMITS	Cracks must be surface connected.
	OTHER CONDITIONS AND LIMITS	Part should be amenable to oil immersion for most applications. Electric discharge.
REFERENCES	PRIMARY SOURCE MATERIAL	References 21 and 22
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM D-1868
	RELATED TERMS	Spark discharge
	RELATED TECHNIQUES	Tesla coil test



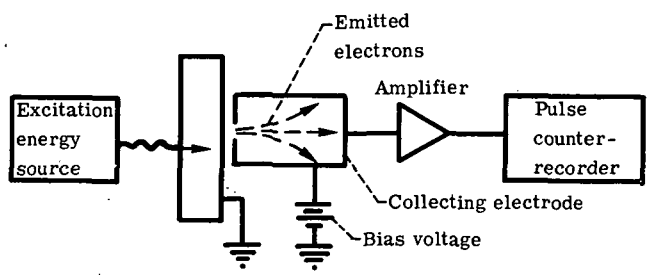
Dielectric

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Displacement of electric charge is induced in part under test. Dielectric properties and/or anomalies are indicated by capacitance and/or polarization effects.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Application of high-frequency electromagnetic field
	NATURE OF SIGNAL AND/OR SIGNATURE	Magnitude and variation of induced displacement current
	DETECTION AND/OR SENSING METHOD	Capacitance bridge
	INDICATION AND/OR RECORDING METHOD	Meter deflection
	INTERPRETATION BASIS	Comparative or differential; requires reference part, material, or standard
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Pinholes, porosity, and leaks
	STRUCTURE OR MALSTRUCTURE	---
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Dielectric constant and dissipation factor
	COMPOSITION AND CHEMICAL ANALYSES	Moisture content and degree of cure
	STRESS AND DYNAMIC RESPONSES	High-frequency power-factor and/or breakdown
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Electroinsulators and dielectrics
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates; plate and sheet forms
	PROCESS CONTROL APPLICATIONS	---
	IN SITU AND DIAGNOSTIC APPLICATIONS	---
	EXAMPLE STRUCTURES AND COMPONENTS	Phenolic and glass-epoxy structures, electrical insulators, sheets and films of resin, paper, and glass
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to only one surface required at close proximity
	PROBE AND OBJECT LIMITS	Probe geometry variable
	SENSITIVITY AND/OR RESOLUTION	Pinhole-size flaws
	INTERPRETATION LIMITS	Ambiguous response to mixed variables
	OTHER CONDITIONS AND LIMITS	Applies best to thin materials
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 23
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	---
	RELATED TECHNIQUES	Corona discharge and microwave



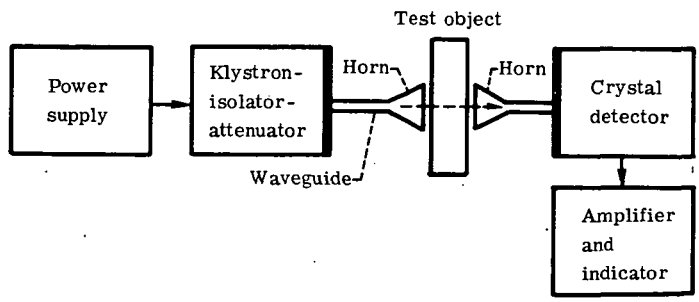
Exo-electron Emission

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Specimen surface is stimulated to emit electrons. Rate of electron emission varies with work function, which varies in turn with surface state and fatigue.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Ultraviolet and/or thermal radiation and ultrasonic vibration
	NATURE OF SIGNAL AND/OR SIGNATURE	Variation of exo-electron current
	DETECTION AND/OR SENSING METHOD	Collecting electrode
	INDICATION AND/OR RECORDING METHOD	Electrometer indication; counter and integrator
	INTERPRETATION BASIS	Comparative or differential; becomes quantitative with reference standard and calibration
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Surface contamination
	STRESS AND DYNAMIC RESPONSES	Fatigue damage and life
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates; uniform and regular surfaces
	PROCESS CONTROL APPLICATIONS	------
	IN SITU AND DIAGNOSTIC APPLICATIONS	------
	EXAMPLE STRUCTURES AND COMPONENTS	Metallurgical specimens (steel, aluminum, and titanium)
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Close access to surface required; no surface films
	PROBE AND OBJECT LIMITS	Probe configuration must accommodate part or surface geometry and methods of excitation
	SENSITIVITY AND/OR RESOLUTION	Sensitive to order of 1 percent variation of fatigue life
	INTERPRETATION LIMITS	Ambiguous response from humidity and/or contamination of surface
	OTHER CONDITIONS AND LIMITS	Experimental technique
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 24
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	----------



Microwave Radiation

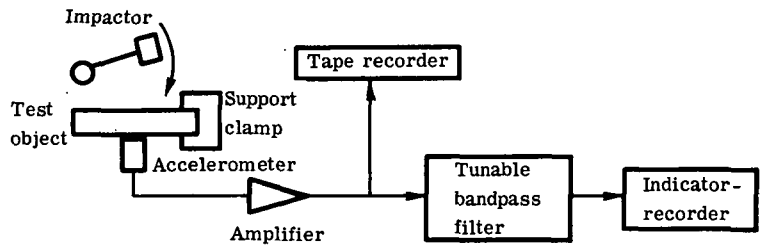
METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Continuous or modulated microwave radiation directed at object propagates according to internal state or structure of part.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Electromagnetic radiation of 3- to 0.03-centimeter wavelength
	NATURE OF SIGNAL AND/OR SIGNATURE	Scatter, reflection, and/or attenuation of radiation
	DETECTION AND/OR SENSING METHOD	Microwave guide and crystal detector
	INDICATION AND/OR RECORDING METHOD	Meter deflection; coordinate plot
	INTERPRETATION BASIS	Comparative, phase-amplitude differentiation; reference standard required
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, porosity, holes, and debonds
	STRUCTURE OR MALSTRUCTURE	Inhomogeneity
	DIMENSIONS AND METROLOGY	Thickness and position
	PHYSICAL AND MECHANICAL PROPERTIES	Dielectric properties
	COMPOSITION AND CHEMICAL ANALYSES	Compositional variations, moisture content, and cure
	STRESS AND DYNAMIC RESPONSES	Vibrational characteristics
	SIGNATURE ANALYSIS	
APPLICATIONS	MATERIALS TO WHICH APPLIED	Plastic, cellulose, ceramic, liquid, and elastomer
	FEATURES AND FORMS TO WHICH APPLIED	Surface, bulk material, and coatings
	PROCESS CONTROL APPLICATIONS	Feedback control of thickness and/or position
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Reinforced plastic structures, polyurethane foam, solid (rocket) propellant, and motor cases
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	No surface contact is required, but positioning of part may be critical.
	PROBE AND OBJECT LIMITS	Alinement and coupling of waveguide and detector is critical; complex waveguide arrangement usual
	SENSITIVITY AND/OR RESOLUTION	Thickness variations to order of 25 micrometers
	INTERPRETATION LIMITS	Spatial resolution for flaws depends on probe (horn) size.
	OTHER CONDITIONS AND LIMITS	Requires metal backing for thickness and position gaging of nonmetals; no microwave hazard at power levels usually used
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 25 (ch. 13)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Dielectric and corona discharge



SONIC-ULTRASONIC TECHNIQUES

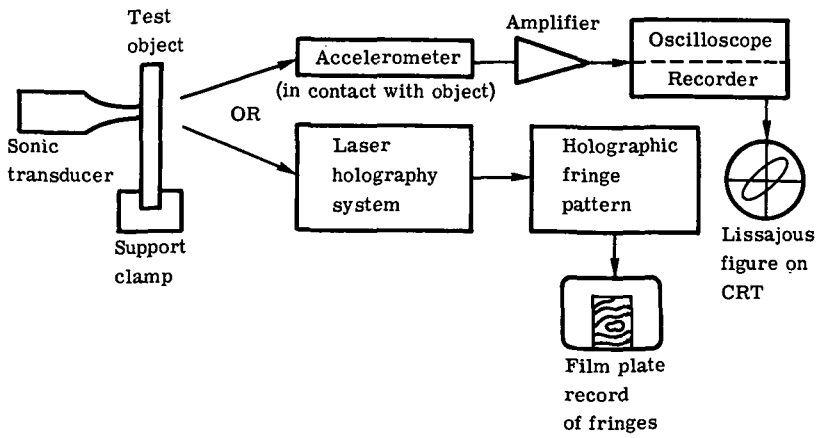
Acoustic-Impact

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Tapping or ringing of object is accomplished by striking it. Mechanically applied pulse causes response vibrations indicative of anomalies and/or flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Impact energy from hammer or pulser
	NATURE OF SIGNAL AND/OR SIGNATURE	Vibrational response and acoustic damping
	DETECTION AND/OR SENSING METHOD	Ear, microphone, and/or accelerometer
	INDICATION AND/OR RECORDING METHOD	Audible sound, meter deflection, and oscilloscope trace
	INTERPRETATION BASIS	Comparative; based on sonic signature vibrational and/or dampening response identification
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, debonds, and delaminations
	STRUCTURE OR MALSTRUCTURE	Macrostructural variations and anomalies
	DIMENSIONS AND METROLOGY	Variations of physical dimensions
	PHYSICAL AND MECHANICAL PROPERTIES	Density, mass, and elastic properties
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Differential dynamic response and damping capacity
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Entire objects, including complex shapes
	PROCESS CONTROL APPLICATIONS	Off-line component testing
	IN SITU AND DIAGNOSTIC APPLICATIONS	Integrity of fasteners, bonds, and cores
	EXAMPLE STRUCTURES AND COMPONENTS	Honeycomb, laminated, brazed, and adhesive-bonded structures; bolted or riveted assemblies, and automotive components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Contact, fixturing, and support of object required
	PROBE AND OBJECT LIMITS	Pulser design and impact point critical
	SENSITIVITY AND/OR RESOLUTION	Low spatial resolution to order of centimeters
	INTERPRETATION LIMITS	Sensitive to ambient and extraneous noise and signals
	OTHER CONDITIONS AND LIMITS	Mass and/or complexity and impact point influence results. All physical and geometric properties but the one tested must be constant.
REFERENCES	PRIMARY SOURCE MATERIAL	References 2 (section 51) and 26
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Impact, shock, tapping, and ringing tests
	RELATED TECHNIQUES	----------



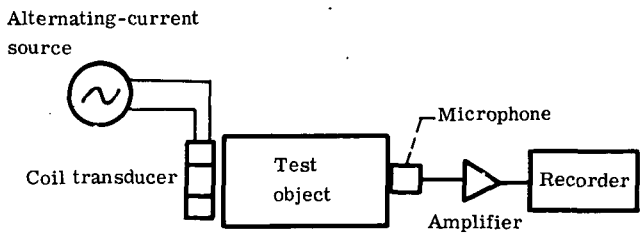
Sonic Vibration

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Continuous sonic vibrations are imparted to object. Induced natural-frequency vibrations of test object reveal flaws and physical property variations.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Periodic force applied by exciter or transducer
	NATURE OF SIGNAL AND/OR SIGNATURE	Resonance and/or harmonic response in 0- to 20-kHz range
	DETECTION AND/OR SENSING METHOD	Microphone and accelerometer or holointerferometry
	INDICATION AND/OR RECORDING METHOD	Meter deflection; oscilloscope or holograph
	INTERPRETATION BASIS	Comparative; frequency-spectrum, Lissajous-pattern or holographic fringe-pattern identification
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Debonds, delaminations, and cracks
	STRUCTURE OR MALSTRUCTURE	Metallurgical variations
	DIMENSIONS AND METROLOGY	Variations in physical dimensions
	PHYSICAL AND MECHANICAL PROPERTIES	Density, elasticity and shear moduli, and Poisson's ratio
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Differential dynamic response and/or damping capacity
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Entire objects; uniform and regular shapes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Solid bars, rods, and disks; abrasive wheels and rods; turbine blade and disks
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Contact, isolation, and support of object required
	PROBE AND OBJECT LIMITS	Pulser and probe design to accommodate part
	SENSITIVITY AND/OR RESOLUTION	Spatial resolution to order of 1 millimeter
	INTERPRETATION LIMITS	Flaw shape and location generally not revealed
	OTHER CONDITIONS AND LIMITS	Object should have definitive vibration modes. Influenced by mass and geometry of object.
REFERENCES	PRIMARY SOURCE MATERIAL	References 2 (section 51) and 27
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Vibration, natural-frequency, and resonance tests
	RELATED TECHNIQUES	----------



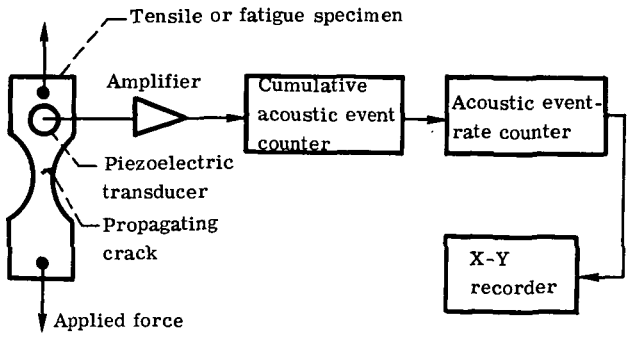
Eddy Sonic Vibration

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Mechanical or sonic vibration is induced in test object by electromagnetic coupling with transducer. Resultant sonic emissions are indicative of flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Eddy currents induced in test object
	NATURE OF SIGNAL AND/OR SIGNATURE	Sonic resonance or chatter characteristic of object
	DETECTION AND/OR SENSING METHOD	Microphone, piezoelectric transducer, and accelerometer
	INDICATION AND/OR RECORDING METHOD	Audio and/or oscilloscope trace or pattern
	INTERPRETATION BASIS	Comparative; sonic signature and/or vibration and resonance pattern identification
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Debonds and delaminations
	STRUCTURE OR MALSTRUCTURE	Malstructure, poor fit, misalinement, and/or loose parts
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and nonconductors joined to metals
	FEATURES AND FORMS TO WHICH APPLIED	Entire objects and structures; regular and uniform shapes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Laminations, bonded metal surfaces, adhesive bonds, and boron-graphite composite structures, metal-faced or metal-core honeycombs
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Close contact with surface required
	PROBE AND OBJECT LIMITS	Probe should fit or accommodate part
	SENSITIVITY AND/OR RESOLUTION	Relatively coarse indication of flaw presence
	INTERPRETATION LIMITS	Ambiguous response to mixed variables
	OTHER CONDITIONS AND LIMITS	Part must contain electroconductor component for coupling with transducer.
REFERENCES	PRIMARY SOURCE MATERIAL	References 28 and 29
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Sonic vibration



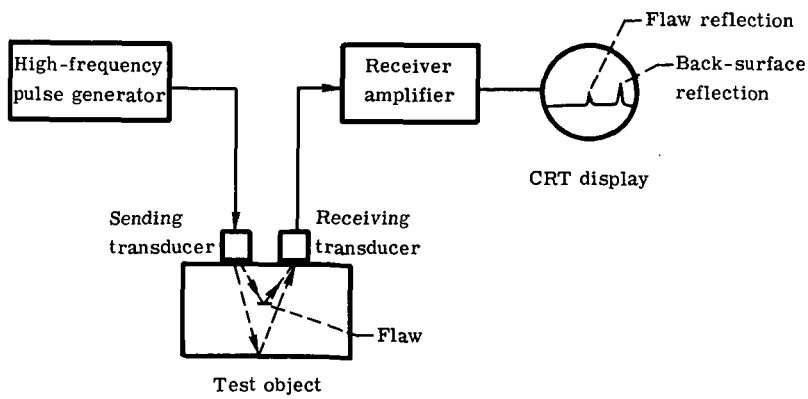
Acoustic Emission

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Phonon signals arise from plastic deformation or fracture. Ultrasonic emission rate and intensity reveals crack initiation and propagation and deformations activated by stressing.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Energy released at deformation or fracture sites
	NATURE OF SIGNAL AND/OR SIGNATURE	Stress or ultrasonic waves propagating in material
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer
	INDICATION AND/OR RECORDING METHOD	Digital counter, meter indication, and coordinate plot
	INTERPRETATION BASIS	Comparative or differential; analysis of emission count rate, amplitude-frequency spectrum, and differential signal arrival time
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Tensile and fatigue properties
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Crack initiation and propagation; strain rate; friction, wear, spalling, and erosion effects; martensitic phase transformation; stress corrosion; and fatigue
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Welds, coatings, bonds, substrates, and entire objects
	PROCESS CONTROL APPLICATIONS	Welding and die-forming; pressure (proof) testing
	IN SITU AND DIAGNOSTIC APPLICATIONS	Incipient failure detection in stressed structures; dynamic monitoring
	EXAMPLE STRUCTURES AND COMPONENTS	Fracture specimens; nuclear, cryogenic, and pressure vessels; aircraft engine components; and fluid systems
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Contact, acoustic coupling, and stressing required
	PROBE AND OBJECT LIMITS	Probe coupling, waveguides, and arrangement critical
	SENSITIVITY AND/OR RESOLUTION	Sensitivity to crack precursors and microcracking under investigation
	INTERPRETATION LIMITS	Multiple probe and computer for flaw location by triangulation required
	OTHER CONDITIONS AND LIMITS	Poor acoustic channels, noise, temperature effects may hamper effective signal extraction. High ductile materials yield poor signals. Requires creation of signature catalog for signal interpretation.
REFERENCES	PRIMARY SOURCE MATERIAL	References 30 and 31
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Stress wave emission
	RELATED TECHNIQUES	Acoustic impact and sonic vibration



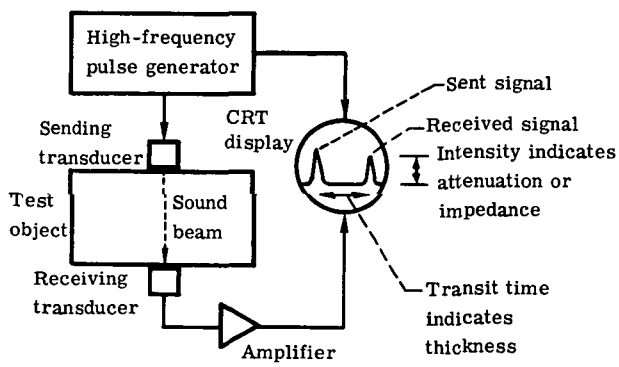
Pulse-Echo Ultrasonics

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Ultrasonic pulses are directed into test object. Ultrasonic echos and reflections indicate presence, absence, and location of flaws, interfaces, and/or discontinuities.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Beam of pulsed ultrasound, 20 kHz to 50 MHz in range
	NATURE OF SIGNAL AND/OR SIGNATURE	Reflection or transmission of pulses or echos
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer(s)
	INDICATION AND/OR RECORDING METHOD	Oscilloscope trace and pulse-echo gating
	INTERPRETATION BASIS	Quantitative for flaw and interface location; reference standards required for calibration and flaw characterization
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, voids, laminations, inclusions, and debonds
	STRUCTURE OR MALSTRUCTURE	Porosity; metallurgical structure and graininess
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Density and sonic velocity
	COMPOSITION AND CHEMICAL ANALYSES	---
	STRESS AND DYNAMIC RESPONSES	Crack growth
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Substrates, joints and bonds, structure components
	PROCESS CONTROL APPLICATIONS	Heat treatment, grinding, and joining and crack monitoring and control
	IN SITU AND DIAGNOSTIC APPLICATIONS	Rolling mill process control and monitoring
	EXAMPLE STRUCTURES AND COMPONENTS	Sheet, plate, bar, and tube stock; castings; forgings; welds; airframe and engine components; pressure vessels; and nuclear reactor components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to one side and liquid coupling to object
	PROBE AND OBJECT LIMITS	Special probes, coupling, and alinement fixtures usual
	SENSITIVITY AND/OR RESOLUTION	Flaws to order of 0.01 millimeter in size
	INTERPRETATION LIMITS	Ambiguous signals may arise as a result of scatter effects, multiple reflections, and geometric complexity.
	OTHER CONDITIONS AND LIMITS	*Small or thin parts are difficult to inspect.*
REFERENCES	PRIMARY SOURCE MATERIAL	References 2 (sections 43, 48, and 49) and 32
	BIBLIOGRAPHICAL MATERIAL	References 33 and 34
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-164-65, E-317-68, E-127-64
	RELATED TERMS	---
	RELATED TECHNIQUES	Transmission, resonance, surface-wave, critical-angle, delta, contact, and immersion ultrasonics



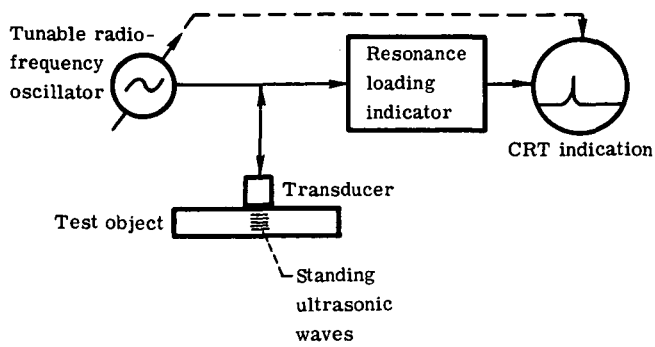
Transmission Ultrasonics

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Continuous, pulsed, or modulated ultrasound transmitted through part is attenuated by flaws and/or interfaces.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Beam of ultrasound (usually 20-kHz to 50-MHz range)
	NATURE OF SIGNAL AND/OR SIGNATURE	Attenuation or obstruction of ultrasound
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer
	INDICATION AND/OR RECORDING METHOD	Meter deflection; oscilloscope trace
	INTERPRETATION BASIS	Comparative or differential; reference standards required for quantitative indications
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, voids, laminations, and inclusions
	STRUCTURE OR MALSTRUCTURE	---
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Density, impedance, and sonic velocity
	COMPOSITION AND CHEMICAL ANALYSES	---
	STRESS AND DYNAMIC RESPONSES	---
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Uniform, regular, and/or flat parts
	PROCESS CONTROL APPLICATIONS	---
	IN-SITU AND DIAGNOSTIC APPLICATIONS	---
	EXAMPLE STRUCTURES AND COMPONENTS	Sheet, plate, and bar stock; laminated structures
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Coupling and access to two sides
	PROBE AND OBJECT LIMITS	Selection, alinement, and fixturing of probes
	SENSITIVITY AND/OR RESOLUTION	Flaws to order of 0.2 millimeter
	INTERPRETATION LIMITS	Spurious signals may arise as a result of reflections, dispersion, or resonance.
	OTHER CONDITIONS AND LIMITS	Poor results unless surfaces are uniform and parallel and only one type of defect is present.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 43 and 49) and 32
	BIBLIOGRAPHICAL MATERIAL	References 33 and 34
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	---
	RELATED TECHNIQUES	Pulse-echo, surface-wave, critical-angle, contact, immersion, and delta ultrasonics



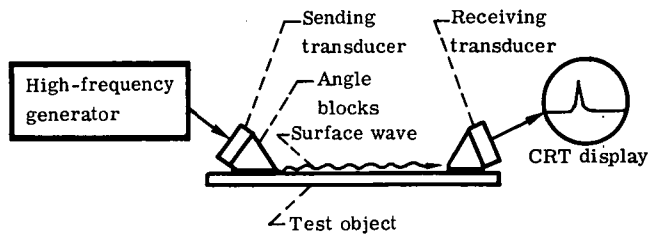
Resonance Ultrasonics

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Frequency is varied until probe introduces continuous and compressional ultrasonic waves into part at resonant frequencies for thickness gaging.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Continuous-wave ultrasound (20-kHz to 25-MHz range)
	NATURE OF SIGNAL AND/OR SIGNATURE	Generation of standing waves and resonance
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer
	INDICATION AND/OR RECORDING METHOD	Meter indication; oscilloscope trace
	INTERPRETATION BASIS	Quantitative; requires catalog of sonic velocities and/or dimensions for thickness and/or velocity measurements
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Delaminations and debonds
	STRUCTURE OR MALSTRUCTURE	Matrix structure variations
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Velocity of sound
	COMPOSITION AND CHEMICAL ANALYSES	---
	STRESS AND DYNAMIC RESPONSES	---
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Homogeneous metals and nonmetals
	FEATURES AND FORMS TO WHICH APPLIED	Platelike forms, tubelike forms, and uniform parts
	PROCESS CONTROL APPLICATIONS	---
	IN SITU AND DIAGNOSTIC APPLICATIONS	Blistering, thinning, and corrosion of pipelines
	EXAMPLE STRUCTURES AND COMPONENTS	Extruded, drawn, or bored tubes; rolled or milled sheetmetal; pressure vessels; ship hulls; boiler tubes; and glass, ceramic, and rigid-plastic parts
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Smooth surface and close coupling preferred
	PROBE AND OBJECT LIMITS	Frequency, type, and mounting of transducer critical
	SENSITIVITY AND/OR RESOLUTION	Thickness variation to order of 0.1 percent
	INTERPRETATION LIMITS	Spurious indications may arise as a result of extraneous vibrational modes, harmonics, end effects, and/or reflections
	OTHER CONDITIONS AND LIMITS	Taper or irregulatities reduce signal value
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 43 and 50) and 32
	BIBLIOGRAPHICAL MATERIAL	References 33 and 34
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-133-67
	RELATED TERMS	---
	RELATED TECHNIQUES	Pulse-echo, transmission, surface-wave, critical-angle, delta, contact, and immersion ultrasonics



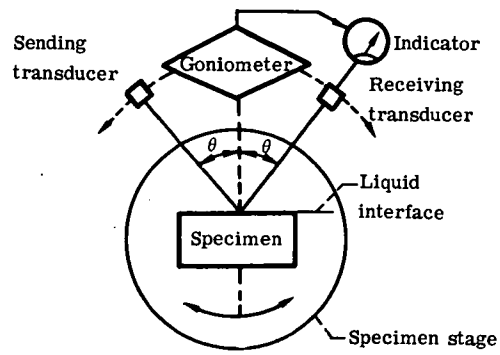
Surface-Wave Ultrasonics

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Ultrasound is introduced into part at specific angle. Waves are totally reflected inside part and travel over the surface to detect surface and surface-connected flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Continuous or pulsed ultrasound to MHz levels
	NATURE OF SIGNAL AND/OR SIGNATURE	Attenuation, damping, or velocity change
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer
	INDICATION AND/OR RECORDING METHOD	Oscilloscope trace
	INTERPRETATION BASIS	Comparative or differential
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks
	STRUCTURE OR MALSTRUCTURE	Roughness, scratches, and graininess
	DIMENSIONS AND METROLOGY	Thickness variation and eccentricity
	PHYSICAL AND MECHANICAL PROPERTIES	-------
	COMPOSITION AND CHEMICAL ANALYSES	-------
	STRESS AND DYNAMIC RESPONSES	Incipient cracking
	SIGNATURE ANALYSIS	-------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Light metals and alloys
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and subsurfaces; smooth and/or uniform shapes
	PROCESS CONTROL APPLICATIONS	High-quality sheetmetal process monitoring
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Aluminum plates and sheets, steel plates and sheets, machine parts, rolled or extruded pieces, and turbine blades
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Contact or coupling with surface
	PROBE AND OBJECT LIMITS	Special angle blocks or wedges required for probe
	SENSITIVITY AND/OR RESOLUTION	Minute surface cracks to order of 0. 1 millimeter deep
	INTERPRETATION LIMITS	Very sensitive to surface roughness
	OTHER CONDITIONS AND LIMITS	Surface waves can be dampened by water, oil, dirt, and/or fingerprints.
REFERENCES	PRIMARY SOURCE MATERIAL	References 2 (section 45) and 35
	BIBLIOGRAPHICAL MATERIAL	Reference 34
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Rayleigh wave ultrasonics
	RELATED TECHNIQUES	Lamb wave ultrasonics



Critical-Angle Ultrasonics

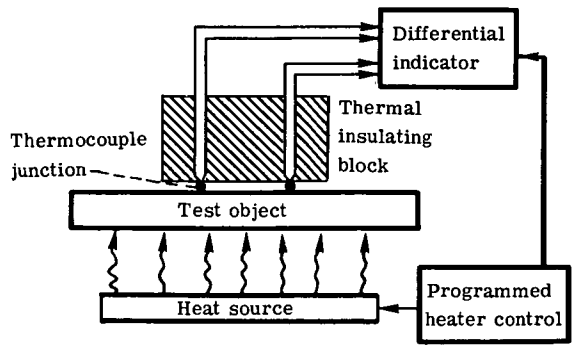
METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Ultrasonic beam is reflected from test surface. Angle of incidence is varied and reflected ultrasound intensity passes through a minimum for an angle that varies with surface and/or substrate properties.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Ultrasound beam at 15 MHz or greater
	NATURE OF SIGNAL AND/OR SIGNATURE	Intensity variation with beam angle of incidence
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer
	INDICATION AND/OR RECORDING METHOD	Goniometer, meter indication, and oscilloscope trace
	INTERPRETATION BASIS	Comparative or differential; calibration or reference standard required
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	Roughness and grain orientation
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Elastic moduli and sonic velocity
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Cold-work, heat-treatment, and annealing effects
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates; coatings and films
	PROCESS CONTROL APPLICATIONS	------
	IN SITU AND DIAGNOSTIC APPLICATIONS	------
	EXAMPLE STRUCTURES AND COMPONENTS	Metallurgical specimens and irradiated reactor materials (steels)
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Liquid coupling to surface by immersion
	PROBE AND OBJECT LIMITS	Special staging of part and probe for goniometry
	SENSITIVITY AND/OR RESOLUTION	Sensitivity under investigation
	INTERPRETATION LIMITS	Ambiguous response from beam spread; side-lobe effects and beam shift.
	OTHER CONDITIONS AND LIMITS	Not useful with complex or very small specimens; experimental technique
REFERENCES	PRIMARY SOURCE MATERIAL	References 26 (ch. 4), 36, and 37
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Reflection ultrasonics
	RELATED TECHNIQUES	Pulse-echo, transmission, resonance, surface-wave, delta, contact, and immersion ultrasonics



THERMAL TECHNIQUES

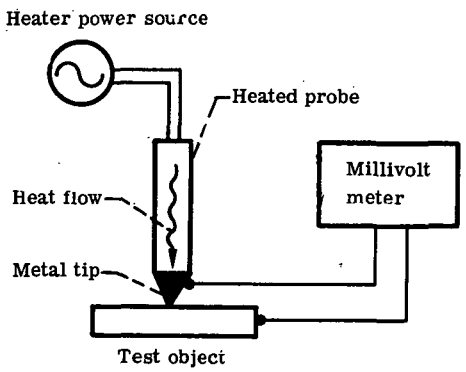
Contact Thermometry

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Measurement of temperature and heat flow variations through test object indicates thermal properties and/or anomalies.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Heat flow
	NATURE OF SIGNAL AND/OR SIGNATURE	Temperature variation
	DETECTION AND/OR SENSING METHOD	Thermocouple, thermistor, and/or thermal comparator; thermosensitive layer
	INDICATION AND/OR RECORDING METHOD	Meter deflection; thermal image
	INTERPRETATION BASIS	Comparative or differential; quantitative reading based on calibration with reference specimen or object
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	---
	STRUCTURE OR MALSTRUCTURE	Roughness
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Thermal time-constant and/or conductivity
	COMPOSITION AND CHEMICAL ANALYSES	---
	STRESS AND DYNAMIC RESPONSES	Case hardening
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and nonmetals (ceramics, mica, quartz, glass)
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, subsurfaces, and bulk; uniform and simple shapes
	PROCESS CONTROL APPLICATIONS	Materials sorting
	IN SITU AND DIAGNOSTIC APPLICATIONS	Implanted in electrical motors and generators
	EXAMPLE STRUCTURES AND COMPONENTS	Experimental specimens; electrical components and equipment
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Contact and attachment to part
	PROBE AND OBJECT LIMITS	May require built-in probes or permanent attachment
	SENSITIVITY AND/OR RESOLUTION	Subject to errors in true temperature response
	INTERPRETATION LIMITS	Sensitive to ambient temperatures, object size and geometry, surface roughness and condition
	OTHER CONDITIONS AND LIMITS	---
REFERENCES	PRIMARY SOURCE MATERIAL	References 39 and 40
	BIBLIOGRAPHICAL MATERIAL	Reference 38
	STANDARDS AND SPECIFICATIONS	ASTM E-235-67, E-220-72, E-230-72 (ref. 4).
	RELATED TERMS	---
	RELATED TECHNIQUES	---



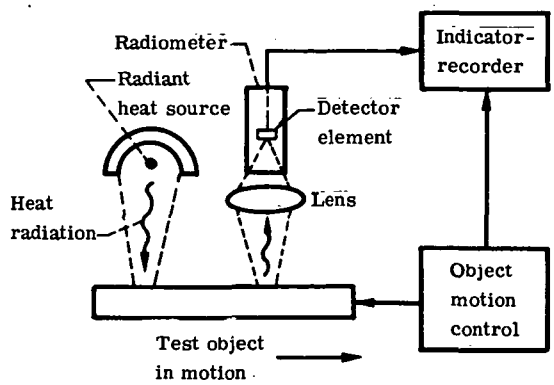
Thermoelectric Probe

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Voltage produced at probe-part contact point due to thermal gradient indicates variations in surface and/or substrate composition.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Thermal gradient produced by heated probe
	NATURE OF SIGNAL AND/OR SIGNATURE	Characteristic bimetallic Seebeck voltage
	DETECTION AND/OR SENSING METHOD	Potentiometric circuit containing part and substrate
	INDICATION AND/OR RECORDING METHOD	Potentiometer
	INTERPRETATION BASIS	Comparative or differential; reference or standard surface required for calibration
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Porosity
	STRUCTURE OR MALSTRUCTURE	Segregations and depletions
	DIMENSIONS AND METROLOGY	Thickness variations
	PHYSICAL AND MECHANICAL PROPERTIES	Thermoelectric properties
	COMPOSITION AND CHEMICAL ANALYSES	Surface chemistry and composition
	STRESS AND DYNAMIC RESPONSES	------
	SIGNATURE ANALYSIS	------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and electroconductive substrates
	FEATURES AND FORMS TO WHICH APPLIED	Subsurfaces and substrates; coatings
	PROCESS CONTROL APPLICATIONS	Metal sorting and coating thickness
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Diffusion coatings and layers, ceramic-coated metals, P-N junctions in semiconductors, and graphite parts
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Uncontaminated surface and tight contact required
	PROBE AND OBJECT LIMITS	Probe tip material, hardness, and oxidation critical
	SENSITIVITY AND/OR RESOLUTION	Voltages in individual metal grains sensed
	INTERPRETATION LIMITS	Contact pressure variations and probe radius variation and dulling limit utility.
	OTHER CONDITIONS AND LIMITS	Primarily experimental technique
REFERENCES	PRIMARY SOURCE MATERIAL	References 41 and 42
	BIBLIOGRAPHICAL MATERIAL	Reference 38
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Thermochromic, infrared radiometry, electrolytic probe, and eddy current



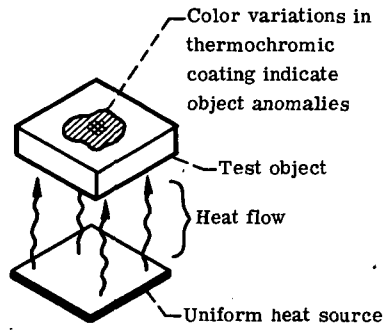
Infrared Radiometry

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Thermal radiation from a heated surface is measured. Active or ambient heating of object reveals heat flow anomalies caused by structure properties and flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Heat injection by radiation, conduction, and/or ohmic heating
	NATURE OF SIGNAL AND/OR SIGNATURE	Perturbation or impedance of heat-flow pattern
	DETECTION AND/OR SENSING METHOD	Radiometer; infrared detector and scanner
	INDICATION AND/OR RECORDING METHOD	Meter deflection; thermal pattern and profile
	INTERPRETATION BASIS	Differential or absolute temperature measurement
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Lack of bond, imbedded material, voids, and porosity
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	Thickness variations
	PHYSICAL AND MECHANICAL PROPERTIES	Emissivity, reflectivity, and temperature
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Heat-transfer characteristics and fatigue cracking
	SIGNATURE ANALYSIS	Isotherms and hot spots
APPLICATIONS	MATERIALS TO WHICH APPLIED	All materials (but usually best for metals)
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, substrates, substructures, and bulk parts
	PROCESS CONTROL APPLICATIONS	Feedback control of welding processes
	IN SITU AND DIAGNOSTIC APPLICATIONS	Heat leaks, degradation and corrosion effects, dynamic monitoring of structures
	EXAMPLE STRUCTURES AND COMPONENTS	Spot welds, coating and plating thickness, adhesive and braze bonds, solar cells, pipe and pressure vessel welds, solid-propellant motor-case bonds, electric and electronic components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	No contact; emissivity coatings may be required.
	PROBE AND OBJECT LIMITS	Fixturing for heating and cooling required; orthogonal view of surface preferred
	SENSITIVITY AND/OR RESOLUTION	Temperature variations to order of 1^{o} C
	INTERPRETATION LIMITS	Poor resolution of flaw area with thick specimens
	OTHER CONDITIONS AND LIMITS	Locates flaw areas; no indication of nature of flaw
REFERENCES	PRIMARY SOURCE MATERIAL	References 25 (ch. 14) and 43
	BIBLIOGRAPHICAL MATERIAL	Reference 38
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Thermochromic and thermography



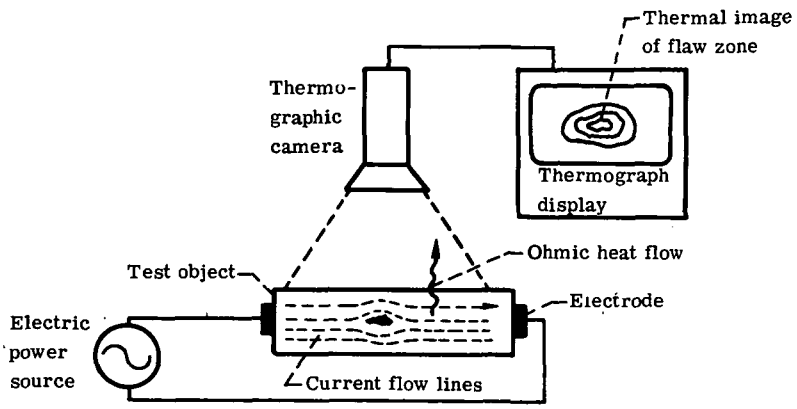
Thermochromic

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Coating of thermosensitive substance is applied to surface. Variations in color reveal anomalies and/or perturbations of heat flow and/or temperature in substrate or bulk.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Application of heat
	NATURE OF SIGNAL AND/OR SIGNATURE	Pattern of color variations of coating
	DETECTION AND/OR SENSING METHOD	Thermochromic paint and liquid crystals
	INDICATION AND/OR RECORDING METHOD	Direct visual and photographic observation
	INTERPRETATION BASIS	Differential, pattern analysis; reference standard required
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks and lack of bond
	STRUCTURE OR MALSTRUCTURE	Heat leads, hot spots, and poor contact
	DIMENSIONS AND METROLOGY	Thickness variations
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Heat-transfer characteristics and isotherms
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and substrates; uniform shapes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	Dynamic monitoring of temperature variations
	EXAMPLE STRUCTURES AND COMPONENTS	Craze and adhesive joints, metallic platings and coatings, crushed core in honeycomb structures, blockage in coolant passages, electrical assemblies, and glass cloth composites
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Surface access required for cleaning and coating
	PROBE AND OBJECT LIMITS	Fixturing for proper heating of test object
	SENSITIVITY AND/OR RESOLUTION	Temperature differences to order of 0.1° C
	INTERPRETATION LIMITS	Critical time-temperature relation
	OTHER CONDITIONS AND LIMITS	Effective temperature range: 0° to 150° C. Image retentivity affected by humidity. Best with thin-walled structures and nonmetal laminates.
REFERENCES	PRIMARY SOURCE MATERIAL	References 44 and 45
	BIBLIOGRAPHICAL MATERIAL	Reference 38
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Thermosensitive paint and cholesteric crystals
	RELATED TECHNIQUES	Infrared radiometry and thermography



Electrothermal

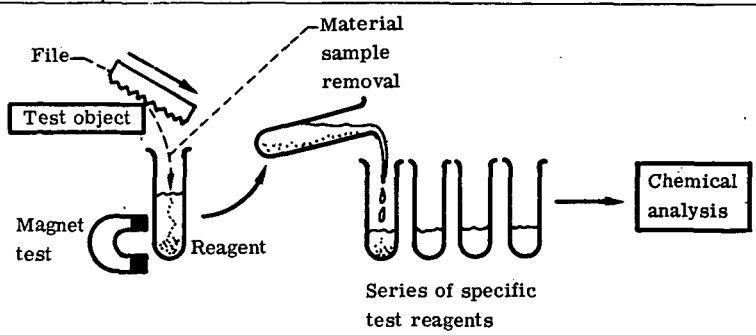
METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Electric current flowing in part generates heat flow that in turn produces surface-temperature variations and/or anomalies indicative of internal flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Ohmic heating by electric current
	NATURE OF SIGNAL AND/OR SIGNATURE	Surface-temperature distribution and pattern
	DETECTION AND/OR SENSING METHOD	Thermosensitive coatings and infrared radiometry
	INDICATION AND/OR RECORDING METHOD	Thermometric indication and thermal imaging
	INTERPRETATION BASIS	Comparative or differential; thermal mapping
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Voids, cracks, and inclusions
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and electroconducting substrates
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and subsurfaces; regular and uniform shapes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Welds, machined parts, plate and sheet materials, turbine blades, and engine components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Visual access to surface and electrode contact required
	PROBE AND OBJECT LIMITS	Electrode contact and spacing tailored to part
	SENSITIVITY AND/OR RESOLUTION	Cracks to order of 0.03 millimeter
	INTERPRETATION LIMITS	Requires combination with other thermal techniques for flaw detection
	OTHER CONDITIONS AND LIMITS	Part should be uniform in region of interest. Sensitivity to thickness variations.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 46
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Infrared radiometry, thermography, and thermochromic



CHEMICAL-ANALYTICAL TECHNIQUES

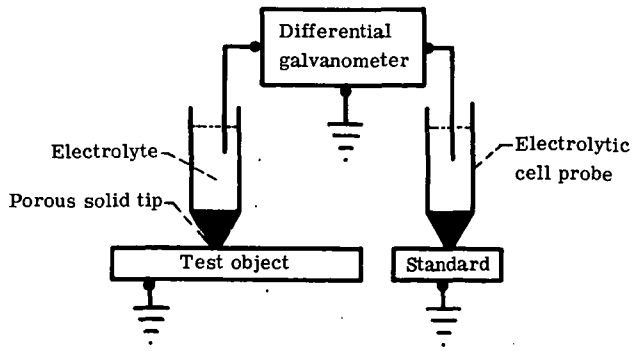
Chemical Spot Test

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Small sample of material is removed from test object to determine its composition. Chemical identifications are made by combining specimen particles with series of reagents.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Chemical reaction
	NATURE OF SIGNAL AND/OR SIGNATURE	Color and/or phase boundary changes; precipitation
	DETECTION AND/OR SENSING METHOD	Visual
	INDICATION AND/OR RECORDING METHOD	Direct observation
	INTERPRETATION BASIS	Qualitative analysis; standardized procedure for reagent preparation and application sequence
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Elemental composition and alloy identification
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and alloys
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and subsurfaces
	PROCESS CONTROL APPLICATIONS	Applied prior to joining and fabrication operations
	IN SITU AND DIAGNOSTIC APPLICATIONS	Metallurgical specimens
	EXAMPLE STRUCTURES AND COMPONENTS	Stock material identification; engine components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Requires semi-microscopic specimen particles from part
	PROBE AND OBJECT LIMITS	Special chemical kit of prepared reagents
	SENSITIVITY AND/OR RESOLUTION	Approximately 150 metals and alloys identified
	INTERPRETATION LIMITS	Assumes particles taken are representative of entire part
	OTHER CONDITIONS AND LIMITS	Difficult to establish quantitative values of constituents detected; minute amount of material removed
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 47
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Spark test and spark oxidation



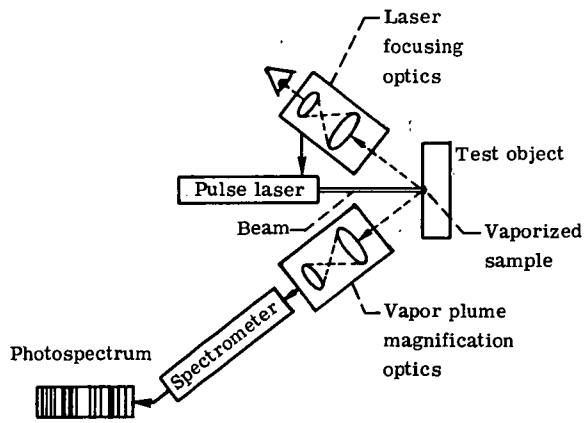
Electrolytic Probe

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Electric potential at probe contact point is used to determine surface composition. Electrolyte-saturated porous probe material produces EMF characteristic of surface anomalies.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Electrolyte-saturated probe
	NATURE OF SIGNAL AND/OR SIGNATURE	Galvanic cell voltage generated on contact
	DETECTION AND/OR SENSING METHOD	Potentiometric circuit containing part
	INDICATION AND/OR RECORDING METHOD	Potentiometer and galvanometer
	INTERPRETATION BASIS	Comparative or differential; qualitative indications depend on catalog of specific chemical reactions
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Inclusions
	STRUCTURE OR MALSTRUCTURE	---
	DIMENSIONS AND METROLOGY	---
	PHYSICAL AND MECHANICAL PROPERTIES	---
	COMPOSITION AND CHEMICAL ANALYSES	Compositional and/or chemical variations
	STRESS AND DYNAMIC RESPONSES	Residual stress
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces
	PROCESS CONTROL APPLICATIONS	Spot checking
	IN SITU AND DIAGNOSTIC APPLICATIONS	---
	EXAMPLE STRUCTURES AND COMPONENTS	Tube, plate, and bar stock
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Surface access and contact required
	PROBE AND OBJECT LIMITS	Depends on choice of electrolyte and probe material
	SENSITIVITY AND/OR RESOLUTION	Sensitivity not established
	INTERPRETATION LIMITS	Chemical identification may be ambiguous
	OTHER CONDITIONS AND LIMITS	Technique not well developed for solids
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 48
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	Electrochemical test
	RELATED TECHNIQUES	Chemical spot test



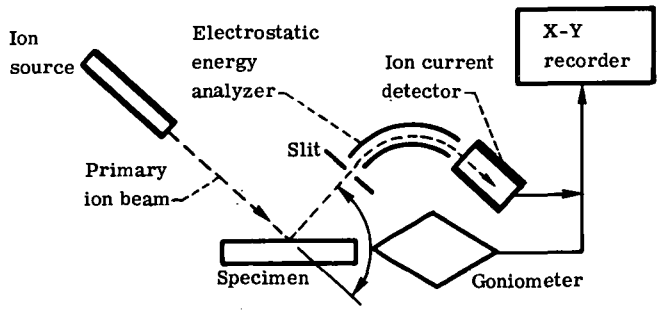
Laser Probe

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Laser beam is microfocused on test object to determine composition and/or microstructure. Minute quantitites of vaporized material are spectroscopically analyzed.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Pulsed laser beam and electroexcitation
	NATURE OF SIGNAL AND/OR SIGNATURE	Ionized vapor plume sample
	DETECTION AND/OR SENSING METHOD	Spectrometer
	INDICATION AND/OR RECORDING METHOD	Spectrograph
	INTERPRETATION BASIS	Differential and/or quantitative analysis
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	Grain and/or microstructure; inclusion, grain, grain-boundary analysis
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Analysis and distribution of elements and impurities
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, subsurfaces, layers, deposits, and coatings
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	Metallurgical specimens and mineral analysis
	EXAMPLE STRUCTURES AND COMPONENTS	Aircraft engine components, jet rotor hubs, and experimental specimens
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Optical view and access to surface required
	PROBE AND OBJECT LIMITS	Focusing and microminiaturization of beam diameter
	SENSITIVITY AND/OR RESOLUTION	Analytical accuracy to order of 5 percent
	INTERPRETATION LIMITS	Depends on control and reproducibility of laser beam diameter and energy
	OTHER CONDITIONS AND LIMITS	Minute amount of material removed
REFERENCES	PRIMARY SOURCE MATERIAL	References 49 to 51
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Laser microprobe
	RELATED TECHNIQUES	Ion probe, ion scatter, and chemical spot test



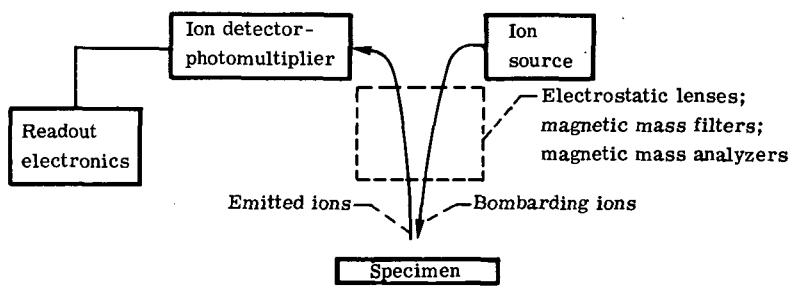
Ion Scatter

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Surface monolayer is bombarded with ion beam to determine chemical composition. Energies of scattered ions are analyzed to identify elemental composition of surface layers.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Monoenergetic beam of noble gas ions
	NATURE OF SIGNAL AND/OR SIGNATURE	Energies of scattered ions altered by surface atoms
	DETECTION AND/OR SENSING METHOD	Ion-current collector and analyzer
	INDICATION AND/OR RECORDING METHOD	Cathode-ray-tube display; coordinate plot
	INTERPRETATION BASIS	Semiquantitative and/or differential; depends on catalog of energies of scatter-ion species
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Analysis, distribution, and profile of elements and impurities
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metal, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, layers, deposits, and coatings
	PROCESS CONTROL APPLICATIONS	Monitoring of surface contamination and/or chemical cleaning
	IN SITU AND DIAGNOSTIC APPLICATIONS	Segregation, diffusion, oxidation, and doping studies
	EXAMPLE STRUCTURES AND COMPONENTS	Insulating layers, electrical relay contacts, steel tubes, and laser-glass (window)
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Part must be placed in vacuum enclosure.
	PROBE AND OBJECT LIMITS	Only small specimens and areas can be accommodated.
	SENSITIVITY AND/OR RESOLUTION	Composition variations to order of 100 ppm
	INTERPRETATION LIMITS	Atomic weights less than that of probe gas are not detected. Material or surface layer must have low vapor pressure.
	OTHER CONDITIONS AND LIMITS	
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 52
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Ion scattering spectrometry
	RELATED TECHNIQUES	Ion probe, laser probe, and Auger analysis



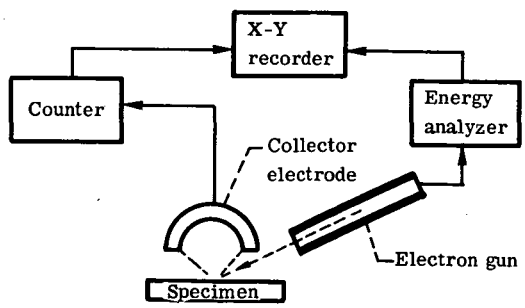
Ion Probe

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Specimen surface atoms are bombarded and ionized to determine chemical composition. Specimen ions are electrostatically impelled through mass analyzer and ion detector.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Positive or negative ion beam (up to about 25 keV)
	NATURE OF SIGNAL AND/OR SIGNATURE	Secondary ions emitted from spot on surface
	DETECTION AND/OR SENSING METHOD	Mass spectrometer and analyzer; ion imager
	INDICATION AND/OR RECORDING METHOD	Cathode-ray-tube display; coordinate plot
	INTERPRETATION BASIS	Spectrographic; semiquantitative; requires library of spectra from standard or reference matrixes
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	Crystalline structure
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Surface physics
	COMPOSITION AND CHEMICAL ANALYSES	Analysis, distribution, and profile of chemicals, elements, and impurities
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Any solid (with low vapor pressure)
	FEATURES AND FORMS TO WHICH APPLIED	Surface, substrates, layers, deposits, and coatings
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Metallurgical specimens, thin films, catalysts, lubricants, and microcircuits
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Insertion of specimen into vacuum enclosure required
	PROBE AND OBJECT LIMITS	Only small specimens or areas can be accommodated.
	SENSITIVITY AND/OR RESOLUTION	Sensitive to order of ppm level
	INTERPRETATION LIMITS	Applied to small areas from 1 to 500 micrometers in diameter
	OTHER CONDITIONS AND LIMITS	Sensitivity depends on atomic species involved; minute amount of material must be removed.
REFERENCES	PRIMARY SOURCE MATERIAL	References 53 and 54
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Ion microprobe
	RELATED TECHNIQUES	Laser probe, ion scatter, and Auger analysis



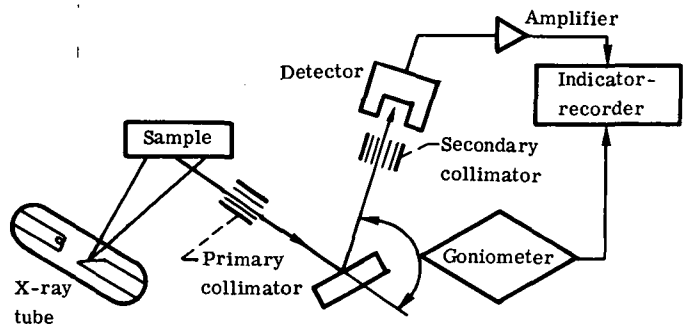
Auger Analysis

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Specimen surface is bombarded with electrons to determine chemical composition. Orbital electrons are excited and emitted with energies characteristic of atoms present in surface layers.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Low-energy electron beam (2- to 3-keV range)
	NATURE OF SIGNAL AND/OR SIGNATURE	Emission of Auger electrons and X-rays
	DETECTION AND/OR SENSING METHOD	Collector, counter, and energy analyzer
	INDICATION AND/OR RECORDING METHOD	Cathode-ray-tube display; coordinate plot
	INTERPRETATION BASIS	Qualitative; spectroanalysis; requires standard spectra relative to various substrates
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Analysis of chemicals, impurities, and segregations
	STRESS AND DYNAMIC RESPONSES	Contamination, corrosion, and diffusion effects; embrittlement and temper
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, alloys, and semiconductors
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, films, and substrates
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Metallurgical specimens, polycrystalline and single-crystal specimens, thin films, and thermionic materials
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Prepared specimen insertion in vacuum enclosure
	PROBE AND OBJECT LIMITS	Only small specimens and areas can be accommodated.
	SENSITIVITY AND/OR RESOLUTION	Maximum sensitivity to order of 100 ppm
	INTERPRETATION LIMITS	Penetration depth limit of about 15 angstroms
	OTHER CONDITIONS AND LIMITS	Materials must have low vapor pressures; poor resolution of adjacent atomic numbers.
REFERENCES	PRIMARY SOURCE MATERIAL	References 55 and 56
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Auger electron emission
	RELATED TECHNIQUES	Ion probe, laser probe, ion scatter, charged-particle activation, and X-ray fluorescence



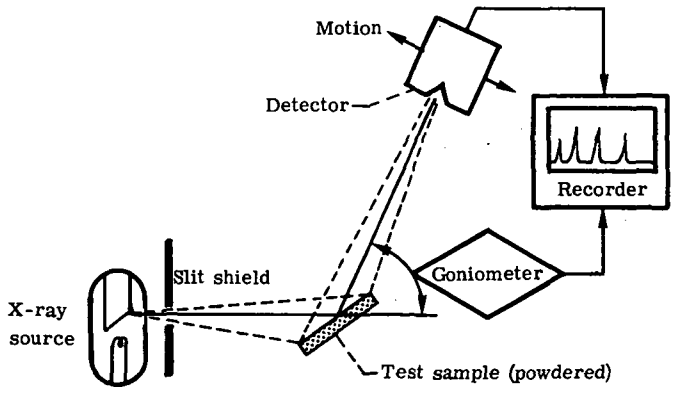
X-Ray Fluorescence

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	X-radiation of specimen surface produces fluorescence, and spectrographic scanning of emissions identifies elemental composition.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	X-radiation to 100-kV level
	NATURE OF SIGNAL AND/OR SIGNATURE	Secondary radiation or fluorescence
	DETECTION AND/OR SENSING METHOD	Crystal analyzer, scintillation, and ionization counter
	INDICATION AND/OR RECORDING METHOD	Coordinate plotter
	INTERPRETATION BASIS	Quantitative spectrographic analysis; based on empirical calibration curves and/or standard specimens
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	---
	STRUCTURE OR MALSTRUCTURE	---
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	---
	COMPOSITION AND CHEMICAL ANALYSES	Elemental analysis and impurities
	STRESS AND DYNAMIC RESPONSES	Corrosion and carburization effects
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals and liquids
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, subsurfaces, coatings, films, and layers
	PROCESS CONTROL APPLICATIONS	---
	IN SITU AND DIAGNOSTIC APPLICATIONS	---
	EXAMPLE STRUCTURES AND COMPONENTS	Metallurgical specimens; raw materials; fuels; solutions; turbine casings, diffusers, and flanges; and aircraft components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Sample or specimen surface preparation
	PROBE AND OBJECT LIMITS	Only small specimens and areas can be accommodated.
	SENSITIVITY AND/OR RESOLUTION	Sensitive to trace elements to order of 0.1 percent
	INTERPRETATION LIMITS	Lower atomic numbers and high sensitivity require vacuum enclosure of specimens.
	OTHER CONDITIONS AND LIMITS	Radiation hazard
REFERENCES	PRIMARY SOURCE MATERIAL	References 2 (section 17) and 57
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	---
	RELATED TECHNIQUES	Auger analysis, ion probe, ion scatter, and charged-particle activation



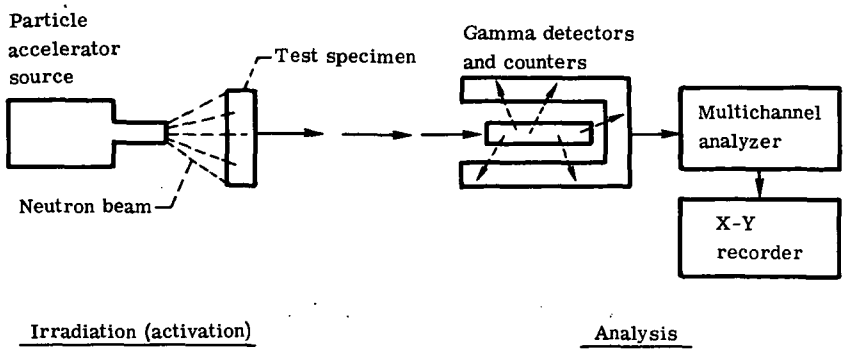
X-Ray Diffraction

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Sample of test object is exposed to X-radiation. Scatter radiation intensity varies with diffraction angles characteristic of crystalline species present.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Monochromatic X-radiation
	NATURE OF SIGNAL AND/OR SIGNATURE	Diffraction pattern
	DETECTION AND/OR SENSING METHOD	Scintillation counter and photoemulsion
	INDICATION AND/OR RECORDING METHOD	Diffractometric photograph and coordinate plot
	INTERPRETATION BASIS	Analytical; differential; dependent on file of reference patterns
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	Crystal size, orientation, structure, and strain; lattice deformation; amorphous structure; phase changes
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Chemical reaction results
	STRESS AND DYNAMIC RESPONSES	Residual stress
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Crystalline materials
	FEATURES AND FORMS TO WHICH APPLIED	Surface specimens (deposits and layers)
	PROCESS CONTROL APPLICATIONS	Manufacture of magnetic and ceramic materials
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Electrodeposited materials, drawn wire, rolled sheet, mineral analysis, and aircraft components
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Powder samples preferred but also applicable to solid parts
	PROBE AND OBJECT LIMITS	Special staging or containment of sample
	SENSITIVITY AND/OR RESOLUTION	Peak-to-background ratio should be >1 to detect low-concentration constituents.
	INTERPRETATION LIMITS	Amorphous constituents may not be detected.
	OTHER CONDITIONS AND LIMITS	Finite crystal sizes in specimen introduce statistical errors in scintillation counting. Radiation hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 17)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	----------



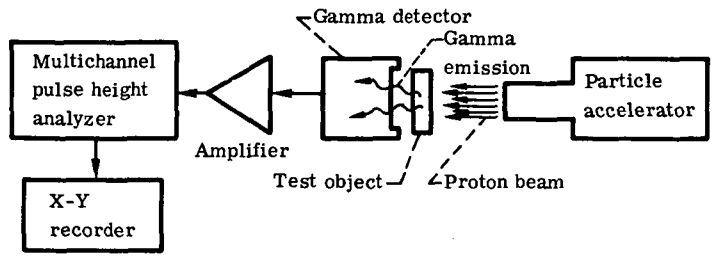
Neutron Activation

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Test object is exposed to neutron flux to determine chemical analysis. Induced radioactivity or emission characterizes and identifies elemental composition of object.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Neutron flux from reactor, accelerator, or radioisotope
	NATURE OF SIGNAL AND/OR SIGNATURE	Characteristic gamma radiation of activated atoms
	DETECTION AND/OR SENSING METHOD	Gamma spectrometer and multichannel analyzer
	INDICATION AND/OR RECORDING METHOD	Oscillogram, spectroplot, and/or computer printout
	INTERPRETATION BASIS	Quantitative and spectrographic; standard or reference spectrum library required
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	Elemental analysis
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Indefinite range of solid and liquid materials
	FEATURES AND FORMS TO WHICH APPLIED	Specimens; uniform and standard samples
	PROCESS CONTROL APPLICATIONS	Off-line process sampling and control
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Oxygen in steel, silicon in metals and ores, and biological and metallurgical specimens
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Enclosure of specimen for maximum sensitivity
	PROBE AND OBJECT LIMITS	Special containment of part for activation
	SENSITIVITY AND/OR RESOLUTION	Sensitive to order of ppm level of constituents
	INTERPRETATION LIMITS	Sensitivity varies directly with irradiation time.
	OTHER CONDITIONS AND LIMITS	Radiation decay in object or specimen is fast.
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 58
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Charged-particle activation



Charged-Particle Activation

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Beam of charged nuclei is projected at test surface to determine composition. Induced gamma emission reveals presence and abundances of elements in matrix or substrate.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Protons of lithium and other nuclei (usually to 2 MeV)
	NATURE OF SIGNAL AND/OR SIGNATURE	Characteristic gamma emission by elements present
	DETECTION AND/OR SENSING METHOD	Detector-counter and energy analyzer
	INDICATION AND/OR RECORDING METHOD	Cathode-ray-tube display; plot of intensity or counts against energy
	INTERPRETATION BASIS	Quantitative; spectrographic; requires library of spectra for various matrixes
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	---
	STRUCTURE OR MALSTRUCTURE	---
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Material identification
	COMPOSITION AND CHEMICAL ANALYSES	Elemental analysis, elemental distribution, and profile
	STRESS AND DYNAMIC RESPONSES	---
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Indefinite range of solid materials
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, substrates, and portions of entire objects
	PROCESS CONTROL APPLICATIONS	---
	IN SITU AND DIAGNOSTIC APPLICATIONS	Early detection of corrosion and oxidation
	EXAMPLE STRUCTURES AND COMPONENTS	Coating thickness, alloy identification, measurement of thin films, trace element detection and laser materials
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Specimen or part is target in charged-particle beam.
	PROBE AND OBJECT LIMITS	Beam collimation, target holder, and direct line access
	SENSITIVITY AND/OR RESOLUTION	Sensitive from percent to order of ppm
	INTERPRETATION LIMITS	Requires knowledge of gamma yields for various matrix materials
	OTHER CONDITIONS AND LIMITS	Some materials may degenerate with ion bombardment. Requires computer for data analysis and display. Radiation hazard.
REFERENCES	PRIMARY SOURCE MATERIAL	References 59 and 60
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	---
	RELATED TECHNIQUES	Laser probe, Auger analysis, ion probe, ion scatter, beta scatter, neutron activation, and X-ray fluorescence



Mössbauer Analysis

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Resonance absorption or emission of gamma radiation is used to determine composition. Gamma photons penetrating substrate detect and/or respond to presence and/or distribution of tracer elements.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Gamma radiation
	NATURE OF SIGNAL AND/OR SIGNATURE	Recoiless re-emission of gamma photons
	DETECTION AND/OR SENSING METHOD	Gamma detector-counter and velocity analyzer
	INDICATION AND/OR RECORDING METHOD	Cathode-ray-tube display; coordinate plot
	INTERPRETATION BASIS	Qualitative, differential spectroanalysis; requires library of reference spectra
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Homogeneity, surface gradients, and dislocations
	STRUCTURE OR MALSTRUCTURE	Lattice surrounding of Mössbauer nuclei
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Magnetic domain polarization and isomer shifts
	COMPOSITION AND CHEMICAL ANALYSES	Mössbauer element detection
	STRESS AND DYNAMIC RESPONSES	Corrosion products
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Material containing Mössbauer elements, usually Fe^{57}
	FEATURES AND FORMS TO WHICH APPLIED	Substrates, coatings, and surface films
	PROCESS CONTROL APPLICATIONS	---
	IN SITU AND DIAGNOSTIC APPLICATIONS	Coating or substrate deterioration
	EXAMPLE STRUCTURES AND COMPONENTS	Fe detection, Fe film on stainless steels, retained austenite in stainless steels, and nitride surfaces on stainless steels
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Close proximity of source and detector to surface
	PROBE AND OBJECT LIMITS	Precise (ultrasonic) vibration of source or part
	SENSITIVITY AND/OR RESOLUTION	Requires liquid-nitrogen temperatures for some species
	INTERPRETATION LIMITS	Depends on seeding or implantation or natural presence of Mössbauer elements or isotopes in substrate
	OTHER CONDITIONS AND LIMITS	Radiation hazard
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 61
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	---
	RELATED TERMS	---
	RELATED TECHNIQUES	Charged-particle activation, neutron activation, backscatter radiometry, ion scatter, ion probe, and Auger analysis

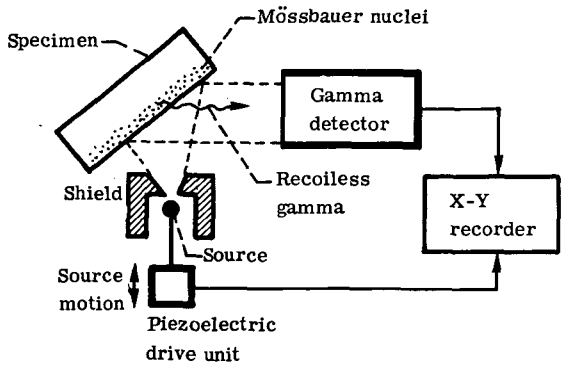


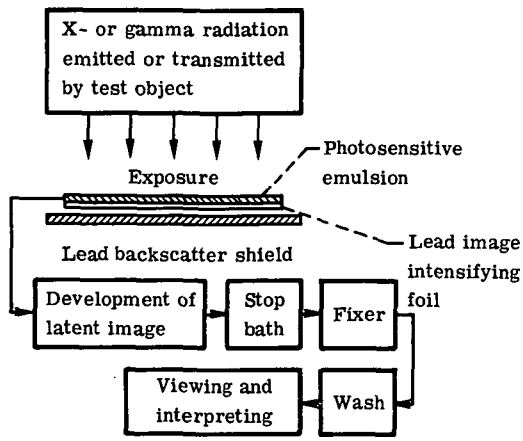
IMAGE GENERATION TECHNIQUES

Photoimaging

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	A range of methods and devices is used for optical imaging. Geometric or wave optics and special illumination are used to extract direct or derivative images of objects.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Natural, artificial, monochrome, coherent, and/or ultraviolet light
	NATURE OF SIGNAL AND/OR SIGNATURE	Reflection, refraction, diffraction, transmission, and/or interference
	DETECTION AND/OR SENSING METHOD	Eye, photocell, photoemulsion, videcon, and/or polarizer
	INDICATION AND/OR RECORDING METHOD	Visual image photograph and projection
	INTERPRETATION BASIS	Direct indication, comparative, or differential; based on collection or library of standard reference images.
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Inclusions, pores, scratches, and mars
	STRUCTURE OR MALSTRUCTURE	Surface anomalies, imperfections, flatness, and form
	DIMENSIONS AND METROLOGY	Thickness variations, orientation, and angle
	PHYSICAL AND MECHANICAL PROPERTIES	Reflectivity and index of refraction
	COMPOSITION AND CHEMICAL ANALYSES	Impurities
	STRESS AND DYNAMIC RESPONSES	Birefringence
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces and interiors (of transparent objects)
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Wide range of applications in metrology; complementary to other NDE techniques
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Visual access and contact
	PROBE AND OBJECT LIMITS	Range of requirements: special optics
	SENSITIVITY AND/OR RESOLUTION	Macro- to micro-optical measurements
	INTERPRETATION LIMITS	----------
	OTHER CONDITIONS AND LIMITS	----------
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 10 to 12)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Photography, infrared photography, and ultraviolet imaging
	RELATED TECHNIQUES	----------

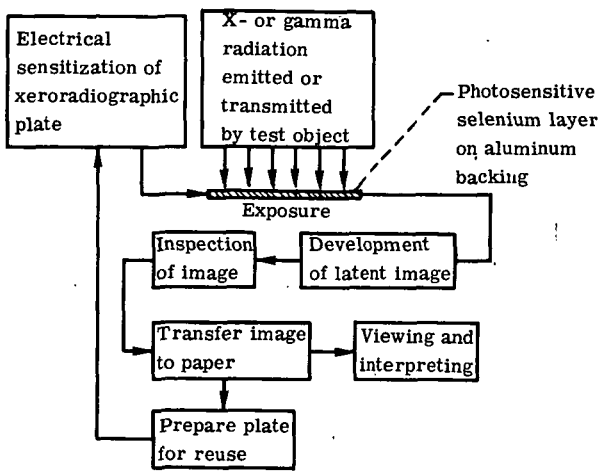
Film Radiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	A photographic image is produced by passage of X-rays, gamma rays, and/or electrons from or through test object onto a film. Changes produced in the film emulsion are developed to yield a radiographic transparency.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	X-rays, gamma rays, neutron activation, electrons, and photons
	NATURE OF SIGNAL AND/OR SIGNATURE	Attenuation, transmission, or emission of radiation
	DETECTION AND/OR SENSING METHOD	Photosensitive emulsion
	INDICATION AND/OR RECORDING METHOD	Radiographic image or transparency
	INTERPRETATION BASIS	Direct indication, comparative, or differential; based on collection or library of standard or reference images
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, inclusions, porosity, voids, and lack of bond
	STRUCTURE OR MALSTRUCTURE	Misalinement and/or malstructure
	DIMENSIONS AND METROLOGY	Thickness, diameter, position, and spacing
	PHYSICAL AND MECHANICAL PROPERTIES	Density
	COMPOSITION AND CHEMICAL ANALYSES	-------
	STRESS AND DYNAMIC RESPONSES	-------
	SIGNATURE ANALYSIS	-------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Range of objects and features.
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Objects of X-, gamma, neutron, and autoradiography; used to obtain neutron radiographs from activated transfer foil
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	One-side access if autoradiography; two if external source
	PROBE AND OBJECT LIMITS	Special filters, screens, and/or scintillators needed for image quality
	SENSITIVITY AND/OR RESOLUTION	Resolution ranges to order of 2000 line pairs per centimeter
	INTERPRETATION LIMITS	Image quality impaired by scatter radiation and finite source or focal-spot-size gamma fogging; requires control of chemicals and photoprocessing conditions for reproducible results
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 20)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	X-, gamma, and neutron radiography; autoradiography; xeroradiography
	RELATED TECHNIQUES	Fluoroscopy and video radiography



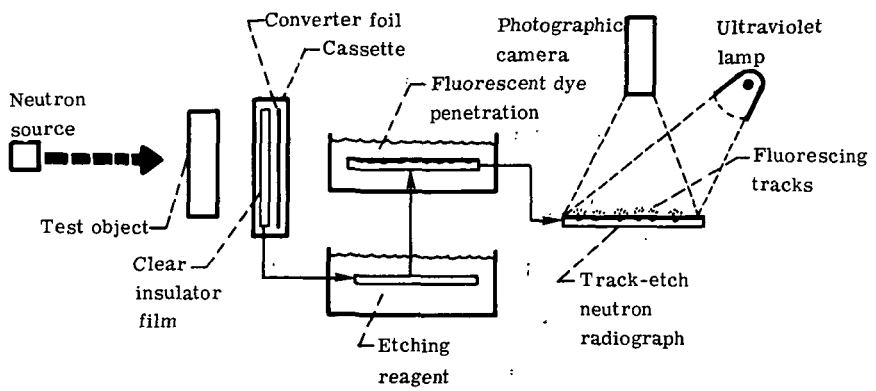
Xeroradiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	An electrostatic image is produced by passage of X- or gamma rays through a test object onto a charged layer. The charge-image is transferred xerographically to form an opaque radiograph.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	X- and gamma rays
	NATURE OF SIGNAL AND/OR SIGNATURE	Attenuation, transmission, or emission of radiation
	DETECTION AND/OR SENSING METHOD	Electrically charged layer
	INDICATION AND/OR RECORDING METHOD	Radiographic image
	INTERPRETATION BASIS	Direct indication, comparative, or differential; based on collection or library of standard or reference images
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, inclusions, porosity, voids, and lack of bond
	STRUCTURE OR MALSTRUCTURE	Misalinement and/or malstructure
	DIMENSIONS AND METROLOGY	Thickness, diameter, position, and spacing
	PHYSICAL AND MECHANICAL PROPERTIES	Density variations
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	Edge enhancement of low-contrast images
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Range of objects and features
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Objects of X- and gamma radiography
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to two sides of test object required
	PROBE AND OBJECT LIMITS	Practical voltage limited to less than 100 kV
	SENSITIVITY AND/OR RESOLUTION	Thickness sensitivity to order of 2 percent
	INTERPRETATION LIMITS	Xeroradiographic plates are easily damaged.
	OTHER CONDITIONS AND LIMITS	Powder- and/or layer-deficient dots and other artifacts hamper image interpretation
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 21)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Film radiography; fluoroscopy; X- and gamma radiography



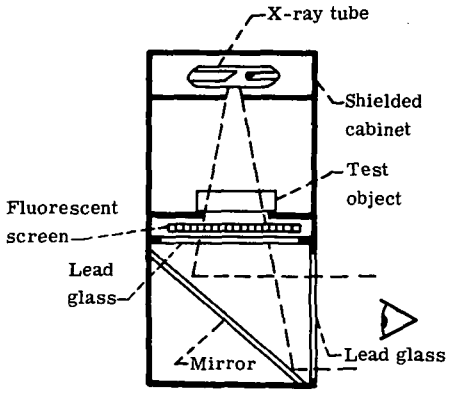
Track-Etch Radiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	A radiographic image is formed by neutrons passing through a test object and activating a metal foil. Ions emitted by the foil penetrate a layer of clear insulator material producing a latent image.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Neutron activation
	NATURE OF SIGNAL AND/OR SIGNATURE	Ion-track damage of insulator material layer and film
	DETECTION AND/OR SENSING METHOD	Etch-removal of damaged material and dye impregnation
	INDICATION AND/OR RECORDING METHOD	Radiographic image
	INTERPRETATION BASIS	Direct indication, comparative, or differential; based on collection or library of standard or reference images
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Voids, porosity, and inclusions
	STRUCTURE OR MALSTRUCTURE	----------
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Neutron dosimetry
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	
APPLICATIONS	MATERIALS TO WHICH APPLIED	----------
	FEATURES AND FORMS TO WHICH APPLIED	----------
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Objects of neutron radiography
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to both sides of test object required
	PROBE AND OBJECT LIMITS	Foil transfer methods, as in neutron radiography, required
	SENSITIVITY AND/OR RESOLUTION	Resolution to order of 0.01 millimeter
	INTERPRETATION LIMITS	Low-contrast image produced requires contrast-enhancement techniques.
	OTHER CONDITIONS AND LIMITS	Experimental technique
REFERENCES	PRIMARY SOURCE MATERIAL	References 62 and 63
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Neutron radiography

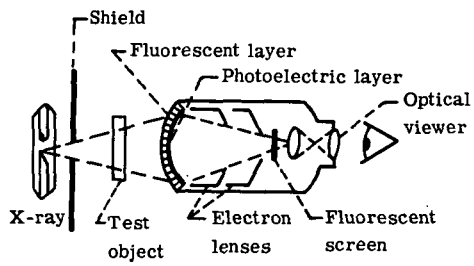


Fluoroscopy

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	A fluorescent image is produced by X-rays passing through a test object onto a fluorescent layer. An immediate and real-time image showing radiographic details appears on a screen.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	X-radiation
	NATURE OF SIGNAL AND/OR SIGNATURE	Attenuation or transmission of radiation
	DETECTION AND/OR SENSING METHOD	Fluorescent chemical layer
	INDICATION AND/OR RECORDING METHOD	Fluorescent image
	INTERPRETATION BASIS	Direct indication; comparative; based on visual impressions
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, porosity, voids, and inclusions
	STRUCTURE OR MALSTRUCTURE	Macro-malstructure and misalinement
	DIMENSIONS AND METROLOGY	Thickness, diameter, spacing, and position
	PHYSICAL AND MECHANICAL PROPERTIES	Density variations
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Effects of distorting forces; dynamic phenomena
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Range of objects and features
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Objects of X-radiography
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to two sides of test object required
	PROBE AND OBJECT LIMITS	Fluoroscopic enclosure limits object size.
	SENSITIVITY AND/OR RESOLUTION	Considerably lower resolution than film radiography
	INTERPRETATION LIMITS	Requires low ambient lighting and eye accommodation
	OTHER CONDITIONS AND LIMITS	Image quality hampered by screen unsharpness, attenuation by windows and mirrors, and fluorescence fluctuations
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (section 19)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	X-radiography and gamma radiography



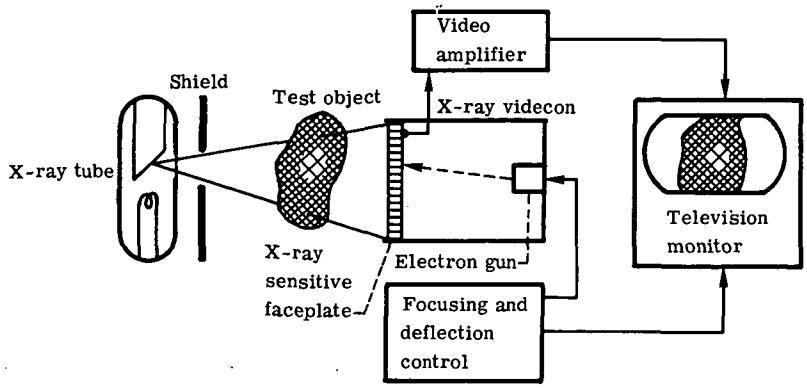
Fluoroscope



Fluoroscopic image amplifier

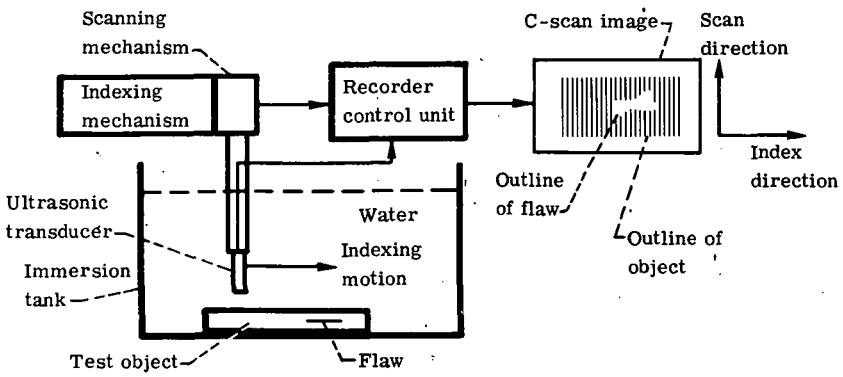
Video Radiography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	X-, gamma-, or neutron-sensitive videcon receives radiation transmitted through test object. Television monitor displays radiographic image.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Neutron rays, gamma rays, or X-rays
	NATURE OF SIGNAL AND/OR SIGNATURE	Transmission or attenuation by object variables
	DETECTION AND/OR SENSING METHOD	Neutron-, gamma-, or X-ray-sensitive vidicon
	INDICATION AND/OR RECORDING METHOD	Television display
	INTERPRETATION BASIS	Direct observation; in-motion, real-time viewing aids interpretation of image content.
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Voids, porosity, inclusions, and cracks
	STRUCTURE OR MALSTRUCTURE	Malstructure and/or misalinement
	DIMENSIONS AND METROLOGY	Dimensional variations
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Direct observation of internal motions of structure; in-motion viewing of flaws
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Indefinite range of materials
	FEATURES AND FORMS TO WHICH APPLIED	Bulk materials and entire objects
	PROCESS CONTROL APPLICATIONS	Real-time viewing of processing and production
	IN SITU AND DIAGNOSTIC APPLICATIONS	In-motion operation of hidden and internal components
	EXAMPLE STRUCTURES AND COMPONENTS	Nuclear fuel pins, casting operations, metal rolling and forming operations, liquid-metal cavitation flow patterns, and submerged welding
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Access to interpose object between source and detector
	PROBE AND OBJECT LIMITS	Useful apertures limited to order of several centimeters
	SENSITIVITY AND/OR RESOLUTION	Thickness variations to order of 4 percent
	INTERPRETATION LIMITS	Usually limited to coarse indication of flaws
	OTHER CONDITIONS AND LIMITS	Inferior to film radiography for fine cracks
REFERENCES	PRIMARY SOURCE MATERIAL	References 25 (ch. 8) and 64
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	X-, gamma, and neutron radiography; fluoroscopy



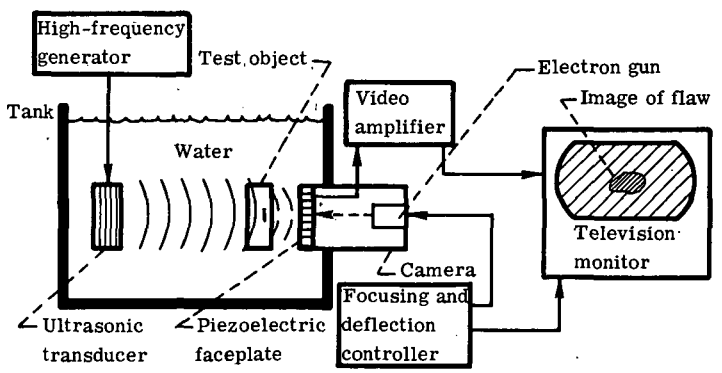
Immersion Ultrasonics

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Test object is ultrasonically scanned while immersed in liquid. Ultrasound interactions with object produce signals that are used to map or image internal flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Beam of pulsed ultrasound (20-kHz to 50-MHz range).
	NATURE OF SIGNAL AND/OR SIGNATURE	Reflection or transmission of ultrasound
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer (or transducers)
	INDICATION AND/OR RECORDING METHOD	Oscillogram; coordinate plots and maps
	INTERPRETATION BASIS	Comparative or differential; quantitative with reference or calibration standards
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, voids, laminations, debonds, and inclusions
	STRUCTURE OR MALSTRUCTURE	Porosity and segregations
	DIMENSIONS AND METROLOGY	Thickness
	PHYSICAL AND MECHANICAL PROPERTIES	Density and velocity of sound
	COMPOSITION AND CHEMICAL ANALYSES	---
	STRESS AND DYNAMIC RESPONSES	---
	SIGNATURE ANALYSIS	---
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Subsurface, bulk, and internal features
	PROCESS CONTROL APPLICATIONS	---
	IN SITU AND DIAGNOSTIC APPLICATIONS	---
	EXAMPLE STRUCTURES AND COMPONENTS	Sheet, plate, bar, and tube items; billets and slabs; engine components; and power transmission shafts
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Liquid immersion and access to at least one surface required
	PROBE AND OBJECT LIMITS	Small, thin, rough-surface parts are difficult to evaluate.
	SENSITIVITY AND/OR RESOLUTION	Discontinuities to order of 0.01 millimeter
	INTERPRETATION LIMITS	Ambiguous response from scatter and geometric complexity
	OTHER CONDITIONS AND LIMITS	Geometrically complex and/or nonregular objects require intricate scanning arrangements
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 2 (sections 44 to 47)
	BIBLIOGRAPHICAL MATERIAL	---
	STANDARDS AND SPECIFICATIONS	Reference 4; ASTM E-214-68
	RELATED TERMS	B-scan and C-scan ultrasonics
	RELATED TECHNIQUES	Ultrasonic videography and ultrasonic holography



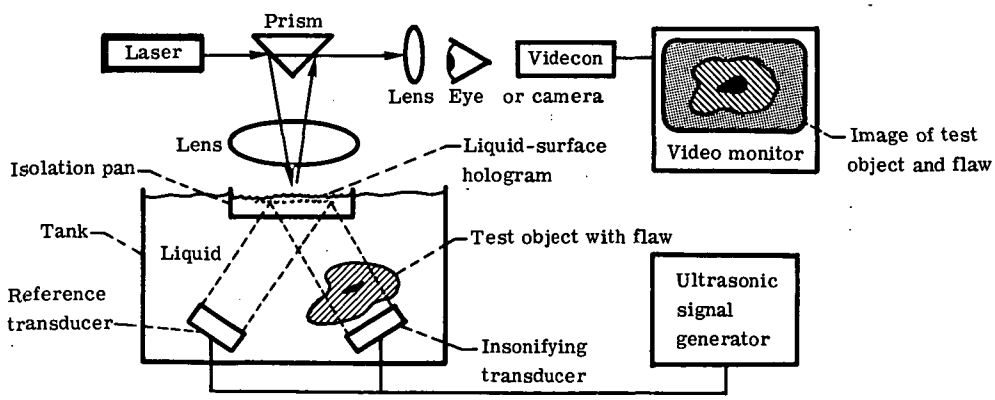
Ultrasonic Videography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Object is illuminated with ultrasound. Ultrasound over an extensive area of object is detected to form an X-ray-like image.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Continuous or pulsed ultrasound at 1 to 10 MHz
	NATURE OF SIGNAL AND/OR SIGNATURE	Transmission or attenuation by object variables
	DETECTION AND/OR SENSING METHOD	Piezoelectric plate or crystal
	INDICATION AND/OR RECORDING METHOD	Direct visual, television monitor, and/or cinematography
	INTERPRETATION BASIS	Direct
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Debonds, lack of bond, and delaminations
	STRUCTURE OR MALSTRUCTURE	Microporosity; grain and crystalline structure
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	Stress patterns
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	In-motion observation of flaws
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and liquids
	FEATURES AND FORMS TO WHICH APPLIED	Bulk and internals
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Metal claddings and coatings, welds, spot welds, nuclear fuel plates, and electron population in semiconductors
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Immersion of test object required
	PROBE AND OBJECT LIMITS	Crystal (diameter) limits area view to order of few centimeters
	SENSITIVITY AND/OR RESOLUTION	Typical sensitivity to order of 0.1 centimeter
	INTERPRETATION LIMITS	Ambiguous response from interference fringes due to Fresnel-Fraunhofer effects
	OTHER CONDITIONS AND LIMITS	----------
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 25 (ch. 3)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Immersion ultrasonics and ultrasonic holography



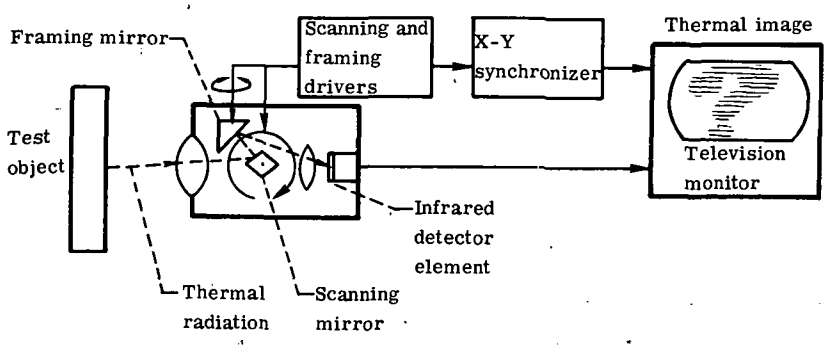
Ultrasonic Holography

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Ultrasound is transmitted through immersed object. Ultrasound modulated by object interacts with reference ultrasound waves to produce liquid-surface hologram of internal flaws.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	(Coherent) ultrasound
	NATURE OF SIGNAL AND/OR SIGNATURE	Interference between transmitted and reference waves
	DETECTION AND/OR SENSING METHOD	Laser holography of liquid-surface hologram
	INDICATION AND/OR RECORDING METHOD	Visual observation of reconstructed hologram
	INTERPRETATION BASIS	Direct indication; based on library of sample images
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, debonds, voids, and inclusions
	STRUCTURE OR MALSTRUCTURE	Malstructure and/or misalinement
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	Real-time acoustic imaging and object manipulation
APPLICATIONS	MATERIALS TO WHICH APPLIED	Range of solid materials
	FEATURES AND FORMS TO WHICH APPLIED	Bulk and internal features
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Bonded and composite structures; biological materials
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Specimen or test object immersion in liquid required
	PROBE AND OBJECT LIMITS	Limited area of object viewable due to transducer size
	SENSITIVITY AND/OR RESOLUTION	Spatial resolution to order of 1 millimeter
	INTERPRETATION LIMITS	Scatter or attenuation can seriously limit utility.
	OTHER CONDITIONS AND LIMITS	Size of detectable flaw increases with increasing thickness of object
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 25 (ch. 5) and 65 to 67
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Acoustic holography
	RELATED TECHNIQUES	Immersion ultrasonics and ultrasonic videography



Video Thermography

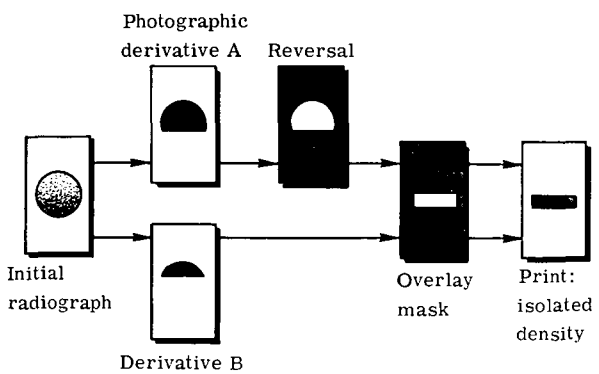
METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Thermal radiation from heated surface is imaged. Radiating surface is raster-scanned, and video image is composed from infrared detector signals.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Infrared radiation emitted by test object
	NATURE OF SIGNAL AND/OR SIGNATURE	Surface-temperature variation or pattern
	DETECTION AND/OR SENSING METHOD	Infrared-sensitive crystal
	INDICATION AND/OR RECORDING METHOD	Video or cathode-ray-tube image
	INTERPRETATION BASIS	Comparative or differential; semiquantitative temperature indication
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Delaminations, debonds, and porosity
	STRUCTURE OR MALSTRUCTURE	--------
	DIMENSIONS AND METROLOGY	Thickness variations
	PHYSICAL AND MECHANICAL PROPERTIES	Emissivity and thermal-conductivity variations
	COMPOSITION AND CHEMICAL ANALYSES	--------
	STRESS AND DYNAMIC RESPONSES	Heat flow
	SIGNATURE ANALYSIS	Thermal mapping and signature
APPLICATIONS	MATERIALS TO WHICH APPLIED	Metals, nonmetals, and composites
	FEATURES AND FORMS TO WHICH APPLIED	Surfaces, entire bulks and objects, wide size range
	PROCESS CONTROL APPLICATIONS	Quality monitoring of microcircuits
	IN SITU AND DIAGNOSTIC APPLICATIONS	Thermal signature of operating equipment
	EXAMPLE STRUCTURES AND COMPONENTS	Composite and laminated panels, solar cells, integrated circuits, and thermal insulators
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Visual access to surface required
	PROBE AND OBJECT LIMITS	Mode and/or uniformity of heat application critical
	SENSITIVITY AND/OR RESOLUTION	Temperature variation to order of 0.1° C
	INTERPRETATION LIMITS	Detector response in wide temperature range is nonlinear.
	OTHER CONDITIONS AND LIMITS	Relatively slow response to thermal fluctuations
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 25 (ch. 14)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Infrared radiometry and thermochromic



SIGNAL-IMAGE ANALYSIS TECHNIQUES

Photographic Extraction

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Photoreprocessing is used to enhance details in images. Photographs and/or radiographs are reproduced with modified density or contrast values to obtain a derivative image.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Light
	NATURE OF SIGNAL AND/OR SIGNATURE	Modulation of light by phototransparency
	DETECTION AND/OR SENSING METHOD	Photoemulsion
	INDICATION AND/OR RECORDING METHOD	Photoreproduction or photoprint
	INTERPRETATION BASIS	Interpretative aid
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, inclusions, voids, and porosity
	STRUCTURE OR MALSTRUCTURE	Structural irregularities and malstructure
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	----------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Radiographs, photographs, and thermographs
	FEATURES AND FORMS TO WHICH APPLIED	Film transparencies
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Objects of original radiography
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Contact photoprinting
	PROBE AND OBJECT LIMITS	Precise registration of overlay film images
	SENSITIVITY AND/OR RESOLUTION	Enhances density differences to order of 0.02 photodensity units.
	INTERPRETATION LIMITS	Fine detail missed to degree of misregistration
	OTHER CONDITIONS AND LIMITS	Control of photoprocessing, chemicals, and temperatures is critical. High quality in original image is required.
REFERENCES	PRIMARY SOURCE MATERIAL	References 68 and 69
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Pseudocolor (photographic) transform
	RELATED TECHNIQUES	----------



Laser Filtering

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Film image is illuminated with laser light. Image is projected through spatial-Fourier filter, and enhanced version of image is reconstructed.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Beam of (coherent) laser light
	NATURE OF SIGNAL AND/OR SIGNATURE	Impression of specimen image content on laser beam
	DETECTION AND/OR SENSING METHOD	Fourier transform spatial filter in focal plane
	INDICATION AND/OR RECORDING METHOD	Photographic reconstruction
	INTERPRETATION BASIS	Interpretive aid; depends on preselected transform parameters used for filtering
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	Structural attributes, properties, and contours
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	Image detail extraction; image analysis and enhancement; pattern recognition and extraction
APPLICATIONS	MATERIALS TO WHICH APPLIED	Photographs and radiographs
	FEATURES AND FORMS TO WHICH APPLIED	Film transparencies
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	Objects of original radiography
	EXAMPLE STRUCTURES AND COMPONENTS	Nuclear fuel radiographs and reconnaissance photographs
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Adequate image detail must be in original image.
	PROBE AND OBJECT LIMITS	Special spatial filter designs required
	SENSITIVITY AND/OR RESOLUTION	Filter design based on known or assumed image content
	INTERPRETATION LIMITS	Depends on quality and content of original image
	OTHER CONDITIONS AND LIMITS	----------
REFERENCES	PRIMARY SOURCE MATERIAL	References 3 (ch. 4) and 70
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Fourier transform holography and holographic image enhancement
	RELATED TECHNIQUES	----------

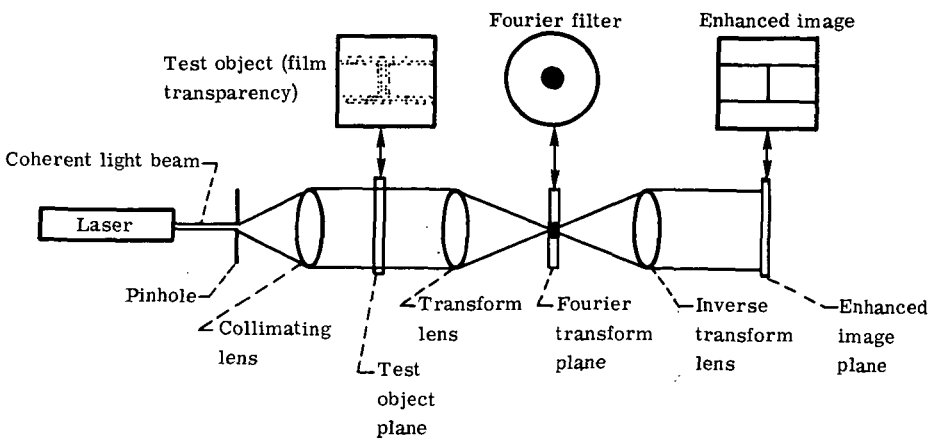
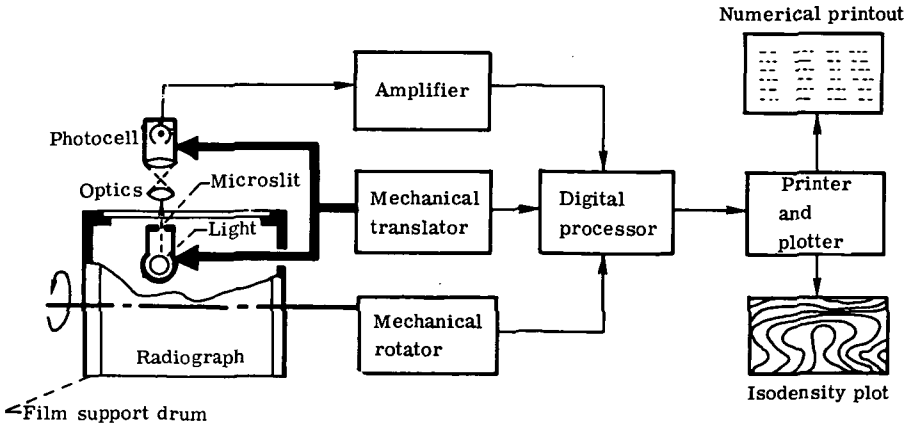


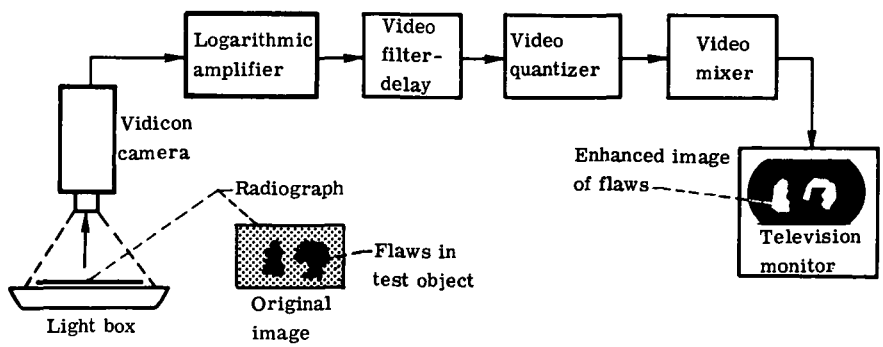
Image Scan Digitization

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Microspot raster-scanning of images is accomplished mechanically. Photograph or radiograph image elements are digitized, analyzed, and reproduced as enhanced hard-copy image derivatives.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Light
	NATURE OF SIGNAL AND/OR SIGNATURE	Attenuation of light by density variations
	DETECTION AND/OR SENSING METHOD	Photocell
	INDICATION AND/OR RECORDING METHOD	Plotter, printer, or facsimile reproducer
	INTERPRETATION BASIS	Interpretational aid; depends on processing parameter settings for varying modes of enhancement
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	----------
	STRUCTURE OR MALSTRUCTURE	Structural anomalies and malstructure
	DIMENSIONS AND METROLOGY	Density and thickness variations
	PHYSICAL AND MECHANICAL PROPERTIES	Elemental analysis
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	Isotherms and thermal mapping; image edge enhancement, densitometry, and quantization
APPLICATIONS	MATERIALS TO WHICH APPLIED	Radiographs, photographs, thermographs, micrographs, spectrographs, and film transparencies and opaques
	FEATURES AND FORMS TO WHICH APPLIED	----------
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Objects of original radiography
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Film or transparency mounted on scanner drum or table
	PROBE AND OBJECT LIMITS	Film or transparency sized to fit scanner format
	SENSITIVITY AND/OR RESOLUTION	Usual sensitivity to order of 65 density increments
	INTERPRETATION LIMITS	Original image quality is limiting factor.
	OTHER CONDITIONS AND LIMITS	Resolution varies with scanner spot size
REFERENCES	PRIMARY SOURCE MATERIAL	References 71 and 72
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Digital image processing
	RELATED TECHNIQUES	Video enhancement, laser filtering, photographic extraction



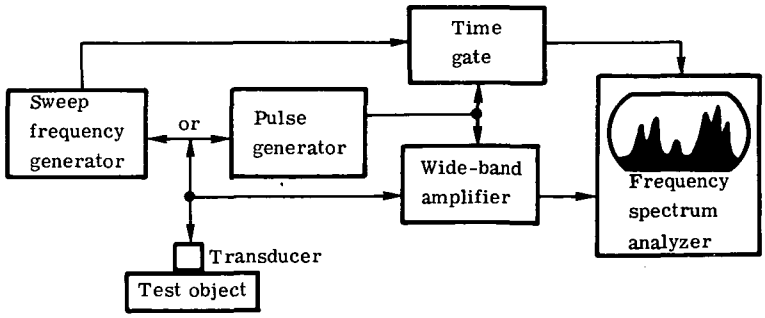
Video Enhancement

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Image is examined with video camera that converts image density values into signals that are enhanced electronically. Derivative image is displayed on television monitor.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Visible light
	NATURE OF SIGNAL AND/OR SIGNATURE	Density variations in original image
	DETECTION AND/OR SENSING METHOD	Videcon camera
	INDICATION AND/OR RECORDING METHOD	Television display
	INTERPRETATION BASIS	Interpretative aid; depends on selection of mode of enhancement
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, voids, inclusions, porosity, etc.
	STRUCTURE OR MALSTRUCTURE	Malstructure and/or misalinement
	DIMENSIONS AND METROLOGY	Dimensional measurements
	PHYSICAL AND MECHANICAL PROPERTIES	Density
	COMPOSITION AND CHEMICAL ANALYSES	-------
	STRESS AND DYNAMIC RESPONSES	-------
	SIGNATURE ANALYSIS	-------
APPLICATIONS	MATERIALS TO WHICH APPLIED	Radiographs, photographs, and metallographs
	FEATURES AND FORMS TO WHICH APPLIED	Transparencies and opaque films
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	Combined with video radiography
	EXAMPLE STRUCTURES AND COMPONENTS	----------
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Presentation of image to camera required
	PROBE AND OBJECT LIMITS	Special lens systems required for various uses
	SENSITIVITY AND/OR RESOLUTION	Density increments to order of 0.05 photodensity units
	INTERPRETATION LIMITS	Usually senses to order of 32 density levels
	OTHER CONDITIONS AND LIMITS	----------
REFERENCES	PRIMARY SOURCE MATERIAL	References 73 and 74
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	----------
	RELATED TECHNIQUES	Photographic extraction, spot scanner-digitizer, and laser filter



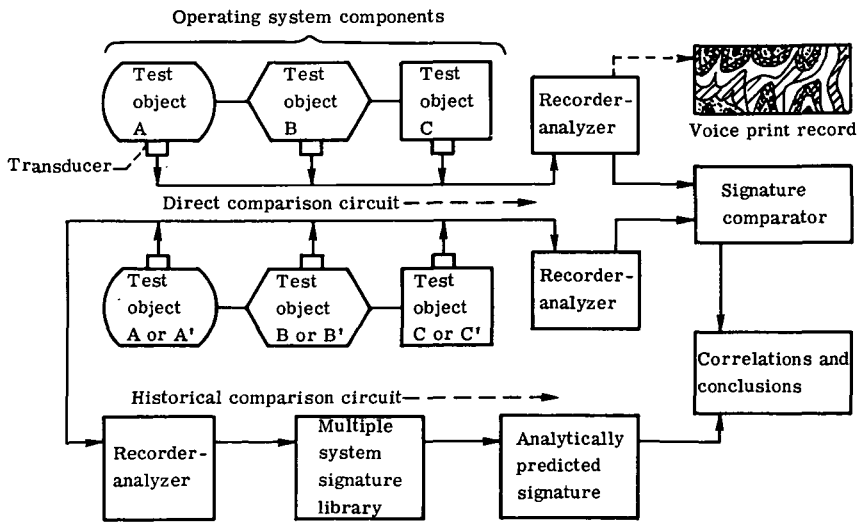
Ultrasonic Spectroscopy

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Object probed with multifrequency ultrasound. Response signals from ultrasonically probed object are analyzed for information on flaw geometry or material microstructure.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Injection of white or frequency-modulated ultrasound
	NATURE OF SIGNAL AND/OR SIGNATURE	Modified transmitted or returned ultrasound spectrum
	DETECTION AND/OR SENSING METHOD	Piezoelectric transducer
	INDICATION AND/OR RECORDING METHOD	Oscilloscope and spectrum analyzer
	INTERPRETATION BASIS	Comparison or differential; based on file or library of frequency response patterns and spectra
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Size, shape, and orientation of discontinuities and inclusions
	STRUCTURE OR MALSTRUCTURE	Crystalline or amorphous microstructure
	DIMENSIONS AND METROLOGY	Thickness gaging and grain-size measurement
	PHYSICAL AND MECHANICAL PROPERTIES	Acoustic attenuation and anisotropy
	COMPOSITION AND CHEMICAL ANALYSES	Material identification and verification
	STRESS AND DYNAMIC RESPONSES	----------
	SIGNATURE ANALYSIS	Classification and testing frequency response signatures of various materials
APPLICATIONS	MATERIALS TO WHICH APPLIED	Crystalline or amorphous metals; nonmetals
	FEATURES AND FORMS TO WHICH APPLIED	Near-surface features; simple geometric shapes
	PROCESS CONTROL APPLICATIONS	----------
	IN SITU AND DIAGNOSTIC APPLICATIONS	----------
	EXAMPLE STRUCTURES AND COMPONENTS	Experimental and metallurgical specimens
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Contact and/or coupling and smooth surface required
	PROBE AND OBJECT LIMITS	Probe frequency response is critical.
	SENSITIVITY AND/OR RESOLUTION	Microstructural variations to order of 0.1 millimeter
	INTERPRETATION LIMITS	Presently an experimental technique
	OTHER CONDITIONS AND LIMITS	----------
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 25 (ch. 2)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Frequency spectrum analysis, waveform analysis
	RELATED TECHNIQUES	----------



Sonic Signature Analysis

METHOD	CONCISE DESCRIPTION OF KEY PROCESS AND BASIC RESULT	Operating noise or vibration patterns emitted by engines and components are analyzed to indicate deviations or deterioration from preestablished norms.
PRINCIPLES	PROBE MEDIUM AND/OR ENERGY SOURCE	Sounds activated by operation
	NATURE OF SIGNAL AND/OR SIGNATURE	Sonic noise or vibration pattern and signature
	DETECTION AND/OR SENSING METHOD	Microphones, accelerometers, and piezoelectric crystals
	INDICATION AND/OR RECORDING METHOD	Coplot of frequency, intensity, and time; voiceprint
	INTERPRETATION BASIS	Comparative; requires library of standard signatures
OBJECTIVES	DISCONTINUITIES AND SEPARATIONS	Cracks, pits, and gouges
	STRUCTURE OR MALSTRUCTURE	Roughness, loose material, and poor fit
	DIMENSIONS AND METROLOGY	----------
	PHYSICAL AND MECHANICAL PROPERTIES	----------
	COMPOSITION AND CHEMICAL ANALYSES	----------
	STRESS AND DYNAMIC RESPONSES	Wear, degradation, abrasion, and/or misalinement
	SIGNATURE ANALYSIS	Excessive or degenerate vibrations
APPLICATIONS	MATERIALS TO WHICH APPLIED	Mixed material combinations
	FEATURES AND FORMS TO WHICH APPLIED	(Internal) functioning parts or components
	PROCESS CONTROL APPLICATIONS	Monitoring of fabrication or processing noise
	IN SITU AND DIAGNOSTIC APPLICATIONS	Monitoring during operation and maintenance of engines
	EXAMPLE STRUCTURES AND COMPONENTS	Aircraft engines, motor vehicles, fluid systems, actuators, solenoids, electro-mechanical devices, and rotating or reciprocating machinery
LIMITATIONS	ACCESS, CONTACT, AND/OR PREPARATION	Good sonic channels through part required
	PROBE AND OBJECT LIMITS	Multiple, selectively placed probes required
	SENSITIVITY AND/OR RESOLUTION	Resolution varies with ambient noise .
	INTERPRETATION LIMITS	Responds to mixed variables
	OTHER CONDITIONS AND LIMITS	Filtering of extraneous frequencies required
REFERENCES	PRIMARY SOURCE MATERIAL	Reference 25 (ch. 7)
	BIBLIOGRAPHICAL MATERIAL	----------
	STANDARDS AND SPECIFICATIONS	----------
	RELATED TERMS	Acoustic signature analysis
	RELATED TECHNIQUES	Acoustic emission and sonic vibration



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ATTRIBUTE-PROPERTY-FLAW INDEX

Use the attribute-property-flaw index to locate specific items for which NDE techniques are sought. The index designates a "specific objective" for each item. Next, locate the specific objective in tables III to X to find techniques applicable to the item of interest. Thus, for example, if techniques for crack detection are sought, refer to "Cracks" in the index, for which the specific objectives are given as "Internal flaws" and "Surface-connected flaws." These specific-objective categories appear in each table (III to X), where applicable techniques are indicated.

Item	Specific Objective
Alloy identification or verification	Metallurgical content
Anneal	Stress, strain, and/or fatigue
Anisotropy	Matrix structure
Assembly errors	Gross structural flaws
Bond, poor	Internal flaws
Cavities	Surface-connected flaws
Chemical reaction	Chemical damage
Coating thickness	Thickness or density
Cohesive force	Magnetic properties
Cold-work	Stress, strain, and/or fatigue
Cold shuts	Surface-connected flaws
Color	Surface properties
Compressive strength or modulus	Mechanical properties
Conductivity, electrical	Electrical properties
Conductivity, thermal	Thermal properties
Contamination	Impurity concentrations
Contour	Dimensional variations
Corrosion	Chemical damage
Corrosion products	Physicochemical state
Crack initiation and propagation	Dynamic performance
Cracks	Internal flaws
Cracks	Surface-connected flaws
Crazing	Surface flaws
Creep	Dynamic performance
Crystalline structure	Microstructure
Cure, degree of	Physicochemical state

Item	Specific Objective
Damage, fatigue	Stress, strain, and/or fatigue
Damping	Dynamic performance
Debonds	Internal flaws
Definition, flaw	Signal or image analysis
Deformation	Gross structural flaws
Deformation, lattice	Microstructure
Deformation, plastic	Dynamic performance
Delaminations	Internal flaws
Densitometry (image)	Signal or image analysis
Density (variations)	Thickness or density
Depletion	Impurity concentrations
Depth, flaw	Displacement and/or position
Detection, elemental	Elemental analysis
Dielectric constant	Electrical properties
Diffusants	Impurity concentrations
Diffusion, isotope or tracer	Radioactive signature
Doping	Impurity concentrations
Dislocation, lattice	Microstructure
Display, flaw	Signal or image analysis
Dissipation factor	Electrical properties
Distribution, elemental	Elemental analysis
Distribution, field	Electromagnetic field
Distribution, filler or reinforcement	Matrix structure
Distribution, flaw	Signal or image analysis
Distribution, isotope or tracer	Radioactive signature
Distribution, temperature	Thermal field
Eccentricity	Dimensional variations
Embrittlement	Mechanical properties
Emission, sonic or ultrasonic	Acoustic signature
Emissivity	Surface properties
Enhancement, image	Signal or image analysis
Erosion	Mechanical damage
Excessive motion	Dynamic performance
Fatigue damage and/or life	Stress, strain, and/or fatigue
Ferromagnetism	Magnetic properties
Field distribution and/or pattern	Electromagnetic field
Filler distribution	Matrix structure

Item	Specific Objective
Film thickness	Thickness or density
Fit, poor	Small structural flaws
Flaw identification and mapping	Signal or image analysis
Flaw size and location	Displacement and/or position
Flow, heat	Thermal field
Folds	Surface-connected flaws
Foreign objects	Small structural flaws
Frequency analysis	Acoustic signature
Friction (effects)	Mechanical damage
Fusion, lack of	Internal flaws
Gap (size)	Displacement and/or position
Gouges	Surface flaws
Grain structure and size	Matrix structure
Hardness	Mechanical properties
Heat contours	Thermal field
Heat flow and leaks	Thermal field
Heat treat	Stress, strain, and/or fatigue
Holes, through	Small structural flaws
Hot spots	Thermal field
Hot tears	Internal flaws
Hydrogen embrittlement	Other damage
Identification, alloy	Metallurgical content
Identification, element	Elemental analysis
Identification, flaw	Signal or image analysis
Image enhancement	Signal or image analysis
Imbedation	Surface flaws
Impregnation	Matrix structure
Inclusions	Internal flaws
Inclusions	Surface-connected flaws
Inclusions	Surface flaws
Index, refraction	Surface properties
Inhomogeneity	Matrix structure
Ion concentration	Physicochemical state
Isotherms	Thermal field
Isotope distribution	Radioactive signature

Item	Specific Objective
Lack of fusion	Internal flaws
Lack of seal	Small structural flaws
Laps	Surface-connected flaws
Lattice structure or strain	Microstructure
Layer, thickness	Thickness or density
Leaks	Small structural flaws
Leaks, heat	Thermal field
Life, fatigue	Stress, strain, and/or fatigue
Linear measurement	Displacement and/or position
Location, flaw	Displacement and/or position
Loose parts or particles	Small structural flaws
Magnetism	Magnetic properties
Malformation	Gross-structural flaws
Mapping, flaw	Signal or image analysis
Mass (variations)	Dimensional variations
Measurement	Displacement and/or position
Misalinement	Gross structural flaws
Missing parts	Gross structural flaws
Moduli	Mechanical properties
Moisture content	Physicochemical state
Molecular structure	Microstructure
Motion, excessive	Dynamic performance
Noise	Acoustic signature
Nonuniformity	Dimensional variations
Ordering, part	Gross structural flaws
Orientation, flaw	Displacement and/or position
Orientation, grain	Matrix structure
Pattern, electric field	Electromagnetic field
Pattern recognition	Signal or image analysis
Permeability	Magnetic properties
Phases, grain	Matrix structure
Phase transformation	Chemical damage
Pinholes	Surface-connected flaws
Pitting	Surface flaws
Plating (thickness)	Thickness or density

Item	Specific Objective
Plastic deformation	Dynamic performance
Poisson's ratio	Mechanical properties
Polarization	Magnetic properties
Poor bond	Internal flaws
Poor spacing	Gross structural flaws
Pores	Internal flaws
Porosity	Surface-connected flaws
Potential, electric	Electromagnetic field
Products, reaction	Metallurgical content
Profile, element	Elemental analysis
Radiation damage	Other damage
Reaction products	Physicochemical state
Refraction index	Surface properties
Reflectivity	Surface properties
Reinforcement (composite)	Matrix structure
Residual stress	Stress, strain, and/or fatigue
Resistivity	Electrical properties
Roughness	Surface flaws
Scratches	Surface flaws
Seal, lack of	Small structural flaws
Seams	Surface-connected flaws
Segregation	Internal flaws
Segregation	Matrix structure
Separation	Displacement and/or position
Separations	Internal flaws
Shape	Dimensional variations
Shear modulus and/or strength	Mechanical properties
Sheet thickness	Thickness or density
Shrinkage	Internal flaws
Signal correlation	Signal or image analysis
Sinter and/or porosity	Matrix structure
Size, flaw	Displacement and/or position
Size, grain	Matrix structure
Size variations	Dimensional variations
Sonic emission	Acoustic signature
Sonic velocity	Mechanical properties
Sorting, alloy	Metallurgical content

Item	Specific Objective
Spacing	Gross structural flaws
Spalling	Mechanical damage
Spectrum, frequency	Acoustic signature
Strain, crystal	Microstructure
Strain, lattice	Internal flaws
Strain, residual	Stress, strain, and/or fatigue
Strength, field	Electromagnetic field
Stress corrosion	Chemical damage
Stress distribution	Stress, strain, and/or fatigue
Stress, residual	Stress, strain, and/or fatigue
Structure, grain	Matrix structure
Structure, lattice	Internal flaws
Structure, molecular	Microstructure
Temper	Mechanical properties
Temperature (distribution)	Thermal field
Tensile modulus and strength	Mechanical properties
Thermal time constant	Thermal properties
Thermoelectric potential	Thermal properties
Thickness (variations)	Thickness or density
Through holes	Small structural flaws
Tracer (isotope)	Radioactive signature
Ultrasonic emission	Acoustic signature
Vacancy, lattice	Microstructure
Variations, size and mass	Dimensional variations
Velocity	Mechanical properties
Verification, alloy	Metallurgical content
Vibration	Dynamic performance
Vibration characteristics	Acoustic signature
Voids	Internal flaws
Voltage breakdown (effects)	Other damage
Wall thickness	Thickness or density
Wear	Mechanical damage
Work hardening	Mechanical properties

TABLE III. - ATTRIBUTES MEASURED OR DETECTED WITH MECHANICAL-OPTICAL NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]									
Main objectives	Specific objectives	Visual-optical	Holointerferometry	Photoelastic coating	Brittle coating	Strain gage	Microhardness	Liquid penetrant	Volatile liquid	Filtered particle	Leak detection
Discontinuities and separations	Surface flaws	A	C	C			C				
	Surface-connected flaws	A	B	B				A	B	A	C
	Internal flaws		A	C							
Structure or mal-structure	Microstructure										
	Matrix structure										
	Small structural flaws	A	C					C			A
	Gross structural flaws	A	C								
Dimensions and metrology	Displacement and/or position	C									
	Dimensional variations	C									
	Thickness or density		B								
Physical and mechanical properties	Electrical properties										
	Magnetic properties										
	Thermal properties										
	Mechanical properties						B				
	Surface properties	A									
Chemical composition and analysis	Elemental analysis										
	Impurity concentrations										
	Metallurgical content										
	Physicochemical state										
Stress and dynamic responses	Stress, strain, and/or fatigue		A	A	A	A					
	Mechanical damage	A									
	Chemical damage	B									
	Other damage										
	Dynamic performance	C	B	B		B					
Signature analysis	Electromagnetic field										
	Thermal field										
	Acoustic signature										
	Radioactive signature										
	Signal or image analysis										

[a]A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TABLE IV. - ATTRIBUTES MEASURED OR DETECTED WITH PENETRATING RADIATION NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]							
Main objectives	Specific objectives	X-radiography	Gamma radiography	Neutron radiography	Penetrating radiometry	Backscatter radiometry	Autoradiography	Radioactive penetrant	Positron annihilation
Discontinuities and separations	Surface flaws								
	Surface-connected flaws							A	
	Internal flaws	B	C	C	C				
Structure or malstructure	Microstructure								E
	Matrix structure								
	Small structural flaws	B	C	C					
	Gross structural flaws	A	A	A					
Dimensions and metrology	Displacement and/or position	A	A	A					
	Dimensional variations	A	A	A					
	Thickness or density	C	C	C	A	A	A		
Physical and mechanical properties	Electrical properties								
	Magnetic properties								
	Thermal properties								
	Mechanical properties								E
	Surface properties								
Chemical composition and analysis	Elemental analysis					C	B		
	Impurity concentrations								
	Metallurgical content								
	Physicochemical state			C					
Stress and dynamic responses	Stress, strain, and/or fatigue								B
	Mechanical damage	C	D	C	B		A	B	
	Chemical damage				D	D	B	C	
	Other damage			D					
	Dynamic performance								
Signature analysis	Electromagnetic field								
	Thermal field								
	Acoustic signature								
	Radioactive signature				B		A	C	
	Signal or image analysis								

[a] A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TABLE V. - ATTRIBUTES MEASURED OR DETECTED WITH ELECTROMAGNETIC-ELECTRONIC NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]										
Main objectives	Specific objectives	Static magnetic field	Magnetic particle	Nuclear magnetic resonance	Barkhausen effect	Eddy current	Electric current	Electrified particle	Corona discharge	Dielectric	Exoelectron emission	Microwave radiation
Discontinuities and separations	Surface flaws							A			A	
	Surface-connected flaws	A	A	D	B	A	A	A	A	C		C
	Internal flaws	C	C			B	B					C
Structure or malstructure	Microstructure			A								
	Matrix structure	C			A	C				C		
	Small structural flaws											
	Gross structural flaws											
Dimensions and metrology	Displacement and/or position											C
	Dimensional variations											
	Thickness or density	A				A	B			B		A
Physical and mechanical properties	Electrical properties					A	A			A		B
	Magnetic properties	A	C			A						
	Thermal properties											
	Mechanical properties	C										
	Surface properties										A	
Chemical composition and analysis	Elemental analysis			C								
	Impurity concentrations			C					C		C	C
	Metallurgical content	B				B						
	Physicochemical state									A		B
Stress and dynamic responses	Stress, strain, and/or fatigue			C	B	B	C				A	
	Mechanical damage						B					
	Chemical damage						B					
	Other damage									B		
	Dynamic performance						B	C				C
Signature analysis	Electromagnetic field	D	C									
	Thermal field											
	Acoustic signature											
	Radioactive signature											
	Signal or image analysis											

[a]A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TABLE VI. - ATTRIBUTES MEASURED OR DETECTED WITH SONIC-ULTRASONIC NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]								
Main objectives	Specific objectives	Acoustic impact	Sonic vibration	Eddy sonic vibration	Acoustic emission	Pulse-echo ultrasonics	Transmission ultrasonics	Resonance ultrasonics	Surface-wave ultrasonics	Critical-angle ultrasonics
Discontinuities and separations	Surface flaws								A	B
	Surface-connected flaws	D				A	C		A	
	Internal flaws	C	C	B		A	B	C		
Structure or malstructure	Microstructure									
	Matrix structure					B		C		B
	Small structural flaws	B	B	B	A					
	Gross structural flaws	C								
Dimensions and metrology	Displacement and/or position					A	C		C	
	Dimensional variations	B	B						C	
	Thickness or density	C	C			C	C	A	B	
Physical and mechanical properties	Electrical properties									
	Magnetic properties									
	Thermal properties									
	Mechanical properties		A	D		B	B	A		B
	Surface properties									
Chemical composition and analysis	Elemental analysis									
	Impurity concentrations									
	Metallurgical content									
	Physicochemical state									
Stress and dynamic responses	Stress, strain, and/or fatigue			D	B				B	A
	Mechanical damage			D		C		C		
	Chemical damage			D						
	Other damage									
	Dynamic performance	C	C	C		A	A			D
Signature analysis	Electromagnetic field									
	Thermal field									
	Acoustic signature	D	B	C	A					
	Radioactive signature									
	Signal or image analysis									

[a]A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TABLE VII. - ATTRIBUTES MEASURED OR DETECTED WITH THERMAL NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]				
Main objectives	Specific objectives	Contact thermometry	Thermoelectric probe	Infrared radiometry	Thermochromic	Electrothermal
Discontinuities and separations	Surface flaws	C				
	Surface-connected flaws		B	B	B	
	Internal flaws			A	C	B
Structure or malstructure	Microstructure					
	Matrix structure		C			
	Small structural flaws					
	Gross structural flaws					
Dimensions and metrology	Displacement and/or position					
	Dimensional variations					
	Thickness or density	C	C	C	C	C
Physical and mechanical properties	Electrical properties					C
	Magnetic properties					
	Thermal properties	B	C	A	C	C
	Mechanical properties	D				
	Surface properties		C	A		
Chemical composition and analysis	Elemental analysis					
	Impurity concentrations		C			
	Metallurgical content					
	Physicochemical state					
Stress and dynamic responses	Stress, strain, and/or fatigue					
	Mechanical damage					
	Chemical damage					
	Other damage					
	Dynamic performance					C
Signature analysis	Electromagnetic field					
	Thermal field	C		A	B	
	Acoustic signature					
	Radioactive signature					
	Signal or image analysis					

[a]A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TABLE VIII. - ATTRIBUTES MEASURED OR DETECTED WITH CHEMICAL-ANALYTICAL NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]										
Main objectives	Specific objectives	Chemical spot test	Electrolytic probe	Laser probe	Ion scatter	Ion probe	Auger analysis	X-ray fluorescence	X-ray diffraction	Neutron activation	Charged-particle activation	Mössbauer analysis
Discontinuities and separations	Surface flaws		C									E
	Surface-connected flaws											
	Internal flaws											
Structure or microstructure	Microstructure			B		B			B			A
	Matrix structure						B		B			
	Small structural flaws											
	Gross structural flaws											
Dimensions and metrology	Displacement and/or position											
	Dimensional variations											
	Thickness or density							C			E	D
Physical and mechanical properties	Electrical properties											
	Magnetic properties											B
	Thermal properties											
	Mechanical properties											
	Surface properties											
Chemical composition and analysis	Elemental analysis	B	D	C	B	B	C	B		B	B	C
	Impurity concentrations		D	B	B	B	C	B	C		B	
	Metallurgical content	B		C	D	D					C	
	Physicochemical state											
Stress and dynamic responses	Stress, strain, and/or fatigue		E				E		A			
	Mechanical damage											
	Chemical damage			B	B	B	D	B	C	C		C
	Other damage											
	Dynamic performance											
Signature analysis	Electromagnetic field											
	Thermal field											
	Acoustic signature											
	Radioactive signature									D		
	Signal or image analysis											

[a] A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TABLE IX. - ATTRIBUTES MEASURED OR DETECTED WITH IMAGE GENERATION NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]									
Main objectives	Specific objectives	Photo-imaging	Film radiography	Xeroradiography	Track-edge radiography	Fluoroscopy	Video radiography	Immersion ultrasonics	Ultrasonic videography	Ultrasonic holography	Video thermography
Discontinuities and separations	Surface flaws	A									
	Surface-connected flaws	C	C					A	C	B	B
	Internal flaws		A	B	C	C	B	A	B	B	B
Structure or mal-structure	Microstructure				E				E		
	Matrix structure							C	D		
	Small structural flaws		B	B		B	B	C	C	C	
	Gross structural flaws		A	A		A	B				
Dimensions and metrology	Displacement and/or position		A	A		C	C	C	C		
	Dimensional variations		A	B		C	B				
	Thickness or density		C	C		D	C	C	D		C
Physical and mechanical properties	Electrical properties										
	Magnetic properties										
	Thermal properties										C
	Mechanical properties							D			
	Surface properties	A									C
Chemical composition and analysis	Elemental analysis										
	Impurity concentrations										
	Metallurgical content										
	Physicochemical state										
Stress and dynamic responses	Stress, strain, and/or fatigue								E		
	Mechanical damage		D	D		D	D				
	Chemical damage										
	Other damage										
	Dynamic damage					C	B		D	D	
Signature analysis	Electromagnetic field										
	Thermal field	C									A
	Acoustic signature										
	Radioactive signature	D	A	D		D	A				
	Signal or image analysis				B		B	D	B	B	B

[a] A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TABLE X. - ATTRIBUTES MEASURED OR DETECTED WITH SIGNAL-IMAGE ANALYSIS

NONDESTRUCTIVE EVALUATION TECHNIQUES

Objectives of nondestructive evaluation		Nondestructive evaluation techniques[a]					
Main objectives	Specific objectives	Photographic extraction	Laser filtering	Image scan digitization	Video enhancement	Ultrasonic spectroscopy	Sonic signature analysis
Discontinuities and separations	Surface flaws						
	Surface-connected flaws	B	D	D	B		
	Internal flaws	B	B	C	B		
Structure or malstructure	Microstructure						
	Matrix structure					E	
	Small structural flaws	C	C	C	B		B
	Gross structural flaws	C	C	C	C		C
Dimensions and metrology	Displacement and/or position	C	C	C	B		
	Dimensional variations						
	Thickness or density						
Physical and mechanical properties	Electrical properties						
	Magnetic properties						
	Thermal properties						
	Mechanical properties						
	Surface properties						
Chemical composition and analysis	Elemental analysis						
	Impurity concentrations						
	Metallurgical content						
	Physicochemical state						
Stress and dynamic responses	Stress, strain, and/or fatigue						
	Mechanical damage	D	D	D	D		B
	Chemical damage						
	Other damage						
	Dynamic performance				B		A
Signature analysis	Electromagnetic field						
	Thermal field						
	Acoustic signature					A	A
	Radioactive signature				A		
	Signal or image analysis	B	B	B	A	A	A

[a]A: very satisfactory technique; B: satisfactory technique; C: restricted usage; D: potential usage; E: experimental.

TECHNIQUE NAME INDEX

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