Nondestructive Tests — SAE J358b

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Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

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PREPRINT

NONDESTRUCTIVE TESTS—SAE J358b

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Nondestructive tests are those tests which detect factors related to the serviceability or quality of a part or material without limiting its usefulness. Material defects such as surface cracks, laps, pits, internal inclusions, bursts, shrink, seam, hot tears, and composition analysis can be detected. Sometimes their dimensions and exact location can be determined. Such tests can usually be made rapidly. Processing results such as hardness, case depth, wall thickness, ductility, decarburization, cracks, apparent tensile strength, grain size, and lack of weld penetration or fusion may be detectable and measurable. Service results such as corrosion and fatigue cracking may be detected and measured by nondestructive test methods. In many cases, imperfections can be automatically detected so that parts or materials can be classified.

TABLE 1—FEATURES OF NONDESTRUCTIVE TESTS

Method	Principle	Material	Applications	Advantages	Limitations
Magnetic particle (SAE J420)	Magnetic particles attracted by leakage flux at surface flaws of magnetic object aid visual inspection.	Magnetic materials	Surface flaws such as cracks, laps, and seams. Some subsurface flaws.	Easy to interpret, fast, simple to perform	Parts must be relatively clean. Usually requires high current source. Parts sometimes must be demagnetized. Standards difficult to establish.
Electromagnetic (eddy current) SAE J425)	Alternating current coil induces eddy currents in test object. Flaws and material properties affect flow of currents. Information derived from meter or cathode ray tube indications.	Metals	Material composition, structure, hardness changes, cracks, case depth, voids, large inclusions, tubing weld defects, laminations, coating thickness, porosity.	Intimate contact between coil and material not required. Versatile. Special coils easily made. Fast operation can be automated. Electric circuit design variations permit selective sensitivity and function. Sensitive to surface and near surface inhomogeneities.	Sensitive to many variables. Sensitivity varies with depth. Reference standards needed. Response often comparative.
Liquid penetrant (SAE J426)	Liquid penetrant is drawn into surface flaws by capillary action, then revealed by developer material to aid in visual inspection.	Nonporous material, metals, plastics, glazed ceramics	Surface flaws such as cracks, porosity, pits, seams, and laps.	Simple to perform, applicable to complex shapes, on site inspection.	Only surface flaws detected. Surfaces must be clean. Penetrant washes out of wide defects. Standards difficult to establish.
Penetrating Radiation (SAE J427)	General—Penetrating radiation is differentially absorbed by materials, depending upon thickness and type of material.	Most materials	Internal defects such as inclusions, porosity, shrink, hot tears, cracks, cold shuts, and coarse structure in cast metals; lack of fusion and penetration in welds. Thickness measurement. Detection of missing internal parts in an assembly.	More standards established than for other methods. Internal defects detected. Permanent film record. Automatic thickness gaging.	Health precautions necessary. Defect must be at least 2% of total section thickness. Film processing requires time, facilities, and care. Difficulty with complex shapes. Most costly nondestructive test method.
	X-ray source produces radiation electrically, by deceleration of electrons.			Versatile—energy adjustable. Fluoroscopy available. Image intensification available. Thickness up to 24 in (600 mm) of steel.	Electric power and water required. Equipment heavy and costly. Shielded area usually required.
	Gamma source produces radiation in decay of radioactive material.			More portable than x-ray. Lower cost than x-ray. Thickness up to 10 in (250 mm) steel can be tested.	Government license required. Energy cannot be adjusted or turned off. Source must be replaced. Orientation affects the test.
Ultrasonic (SAE J428)	Mechanical vibrational waves (frequency range 0.1-25 MHz are introduced into a test object. This energy is reflected and scattered by inhomogeneities or becomes resonant. Information is interpreted from cathode ray tube or read from meter.	Metals, plastics, ceramics, glass, rubber, graphite, concrete	Inclusions, cracks, porosity, bursts, laminations, structure, lack of bond, thickness measurement, weld defects.	Variety of inspection elements and circuitry permits selective high sensitivity. High speed test. Can be automated and recorded. Penetrates up to 60 ft (18 m) steel. Indicates flaw location. Access to only one surface usually needed.	Difficulty with complex shapes. Surface roughness may affect test. Defect orientation affects test. Comparative standards only. Requires couplant.
Infrared (SAE J359)	Electromagnetic radiation from test objects above a temperature of absolute zero is detected and correlated to quality. Information is displayed by meter, recorder, photograph or, CRT.	Most materials	Discontinuities that interrupt heat flow: flaws, voids, inclusions, lack of bond. Higher or lower than normal resistances in circuitry.	High sensitivity. One-sided inspection possible. Applicable to complex shapes and assemblies of dissimilar components. Active or passive specimens.	Emissivity variations in materials, coatings and colors must be considered. In multilayer assemblies, hot spots can be hidden behind cool surface component. Relatively slow.

The SAE Handbook describes the following nondestructive test methods:

SAE J359	Infrared
SAE J420	Magnetic Particle
SAE J425	Eddy Current
SAE J426	Liquid Penetrant
SAE J427	Penetrating Radiation
SAE J428	Ultrasonic
SAE J1242	Acoustic Emission Test Methods

Table 1 summarizes the principal features of these tests. In addition to the tests described, other nondestructive tests exist which are less well established, but whose use is expanding. Among these are microwave tests, holography, and acoustic emission. Microwaves are used to locate defects in nonmetallic substances and to determine some physical characteristics of those materials. Optical holography uses coherent light from a laser beam to detect strains and defects in materials by means of three-dimensional imaging and interferometry techniques. Acoustical holography uses ultrasonic waves to image discontinuities in the interior of solids. Acoustic emission is the noise produced by the generation and/or propagation of a microcrack. Recent refinements in sonic testing permit more objective determination of the physical properties of cast iron. Complete information concerning each nondestructive test can be obtained from books listed in the bibliographies of the aforementioned reports.

Increasing consumer demand for product quality at reasonable cost has resulted in development of nondestructive tests which can be applied to materials and manufactured parts. Although a variety of complementary nondestructive methods is available, development time is generally required for application to specific materials or products. The effect of part contour, surface condition, heat treatment, composition variation, and other variables may limit the ability of certain tests to detect imperfections with desired accuracy.

Nondestructive tests properly applied to basic material can add greater assurance of performance to design strengths, thereby affecting material and manufacturing economy. In addition, parts can be tested after each basic operation which is critical to service performance of the finished part. In-process nondestructive tests can also serve as basic components of feedback process control systems since all tests are based upon measurements which do not damage the material or part being inspected.