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SURFACE VEHICLE INFORMATION REPORT

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(R) NONDESTRUCTIVE TESTS

Foreword—This Document has also changed to comply the new SAE Technical Standards Board Format.

1. Scope—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.

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
SAE J1267—Leakage Testing

Table 1 summarizes the principal features of most 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 sonic tests. 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. 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.

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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.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the lastest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J369—Infrared Testing
SAE J420—Magnetic Particle Inspection
SAE J425—Electromagnetic Testing by Eddy Current Methods
SAE J426—Liquid Penetrant Test Methods
SAE J427—Penetrating Radiation Inspection
SAE J428—Ultrasonic Inspection
SAE J1242—Acoustic Emission Test Methods
SAE J1267—Leakage Testing

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 and 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, and conductivity	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. 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 non-destructive test method.
	X-ray source produces radiation electrically, by deceleration of electrons.			Versatile-energy adjustable. Fluoroscopy available. Image intensification available. Thickness up to 600 mm (24 in) of steel.	Electric power and water required. Equipment heavy and costly. Shielded area usually required.
	Gamma source produces radiation as a result of decay of radioactive material.			More portable than x-ray. Lower cost than x-ray. Thickness up to 250 mm (10 in) steel can be tested.	Government license required. Energy cannot be adjusted or turned off. Source must be replaced. Orientation affects the test.

TABLE 1—FEATURES OF NONDESTRUCTIVE TESTS ((CONTINUED)

Method	Principle	Material	Applications	Advantages	Limitations
	Neutron source produces radiation by nuclear reactors, accelerators, or decay of radioactive material.			Penetrates dense metals but is attenuated by light elements such as in water, plastics, and oil. Usable on radioactive objects.	Government license required. Less portable and more expensive than x-ray.
Ultrasonic (SAE J248)	Mechanical vibrational waves (frequency range 0.1 to 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 (18m) 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.
Acoustic Emission (SAE J1242)	Acoustic emission is a transient elastic wave generated by rapid release of energy from a localized source within a solid material. Rate and amplitude of high frequency (0.1 to 1 MHz) acoustic emissions are noted and correlated to structure or object characteristics.	Most soild materials	Determine or monitor integrity of structures such as weldments or castings.	Remote and continuous real time surveillance of structures is possible. Inaccessible flaws can be detected. Location of flaws can be determined. Permanent record can be made.	Part must be stressed. Nonpropagating flaws cannot be detected. Nonrelevant noise must be filtered out. Transducers must be placed upon the object.
Leakage Testing (SAE J1267)	Material flows across an interface at a leak site. Rate of flow is pressure, time, and leak size dependent. Detection of the trans interface migration is done in one of eight or more ways.	Totally independent of materials.	Any vessel containing a product at a pressure different from ambient or a vessel in which a pressure different from ambient can be created for evaluation.	Provides assurance that the vessel will retain contents as designed. Advantages vary for the individual methods.	Vary from method to method.

3. Notes

3.1 Marginal Indicia—The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

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