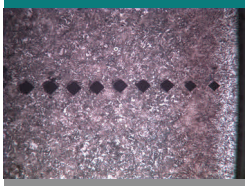
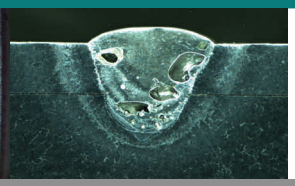
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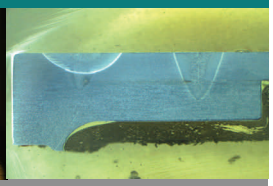

Industry Definitions

Abrasive wear: The removal or displacement of material from a surface when hard particles slide or roll across the surface under pressure. The particles may be loose or may be part of another surface in contact with the surface being worn. Contrast with *adhesive wear*.

Absorption (of electromagnetic radiation): A decrease in the intensity of the beam (light, x-rays, electrons and so on) when passing through matter. In many cases specific wavelengths or energies are preferentially absorbed forming the basis of absorption spectroscopy.

Accelerating voltage: In various electron beam instruments and x-ray generators, the difference in potential between the filament (cathode) and the anode, causing acceleration of the electrons by 2 to 30 KeV.

Accuracy: The degree of agreement of a measured value with the true or correct value for the quanity being measured.

Adsorption chromatography: Chromatography based on differing degrees of adsorption of sample compounds onto a polar stationary phase.

Adhesive wear: The removal or displacement of material from a surface by the welding together and subsequent shearing of minute areas of two surfaces that slide across each other under pressure. In advanced stages, may lead to galling. Contrast with *abrasive wear*.

Amorphous solid: A rigid material whose structure lacks crystalline periodicity, that is, the pattern of its constituent atoms or molecules does not repeat periodically in three dimensions.

Analyte: In any analysis, the substance (element, ion, compound) being identified or determined.

Analytical Chemistry.: The science of chemical characterization and measurement. Qualitative analysis is concerned with the description of chemical composition in terms of elements, compounds, or structural units; quantitative analysis is concerned with the precise measurement of amount. A variety of physical measurements are used, including methods based on spectroscopic, electrochemical, radiochemical, chromatographic, and nuclear principles.

Anion: An ion that is negatively charged and moves toward the positive pole (anode) during electrolysis.

Anisotropy: A variation in the mechanical properties of a material relative to direction.

Aromatic: In organic chemistry, pertaining to or characterized by the presence of at least one benzene ring.

Asperity: In *tribology*, a protuberance in the small-scale topographical irregularities of a solid surface.

Atom: The smallest particle of an element that retains the characteristic properties and behavior of the element.

Atomic number: The number of elementary positive charges (protons) contained within the nucleus of an atom. For an electrically neutral atom, the number of planetary electrons is also given by the atomic number.

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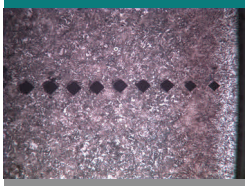
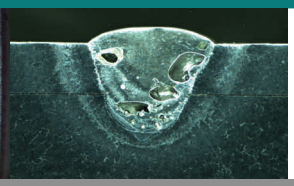
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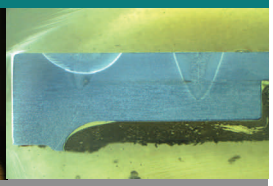

Industry Definitions

Atomic weight: A number assigned to each chemical element that specifies the average mass of its atoms. Because an element may consist of two or more isotopes, each having atoms with well defined but differing masses, the atomic weight of each element is the average of the masses of its naturally occuring isotopes weighted by the relative proportions of those isotopes.

Auger Electron Spectroscopy (AES): A technique for chemical analysis of surface layers that identifies the atoms present in a layer by measuring the characteristic energies of their auger electrons.

Austenite: A non-magnetic solid solution of carbon in face centered cubic (Gamma Iron). With appropriate alloying the phase can be stable at room temperature such as in 300 series of stainless steels

Axial strain: Increase (or decrease) in length resulting from a stress acting parallel to the longitudinal axis of the specimen.

Background: Any noise in the signal due to instabilities in the system or to enviromental interferences.

Backscattered electron: An information signal arising from elastic (electron-nucleus) collisions, wherein the incident electron rebounds from the interaction with a small energy loss. The backscattered electron yield is strongly dependent on atomic number, qualitatively describes the origin of characteristic rays, and reveals compositional and topographical information about the specimen.

Bainite: One of the decompositions products that can occur when austenite is cooled past a critical temperature of 727° C. It is a fine dispersion of carbide in ferrite upper Bainite forms below 450° to 500° C, lower Bainite below 350°C.

Bauschinger effect: The phenomenon by which plastic deformation increases yield strength in the direction of plastic flow and decreases it in other directions.

Beach marks: Progression marks on a facture surface that indicate successive position of the advancing crack front. The classic appearance is of irregular elliptical or semielliptical rings, radiating outward from one or more origins. Beach marks (also known as clamshell marks or tide marks) are typically found on service fractures where the part is loaded randomly, intermittently, or with periodic variations in mean stress or alternating stress.

Bearing area: The product of the pin diameter and specimen thickness.

Bearing strain: The ratio of the bearing deformation of the bearing hole, in the direction of the applied force, to the pin diameter.

Bearing strength: The maximum bearing stress that a material is capable of sustaining.

Bearing stress: The force per unit of bearing area.

Bearing test: A method of determining the response to stress (load) of sheet products that are subjected to riveting, bolting, or a similar fastening procedure. The purpose of the test is to determine the bearing strength of the material and to measure the bearing stress versus the deformation of the hold created by a pin or rod of a circular cross section that pierces the sheet perpendicular to the surface.

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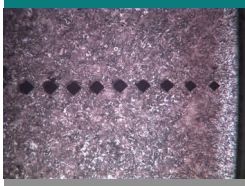
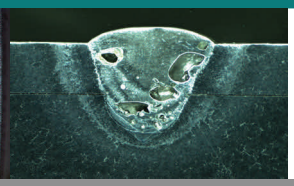
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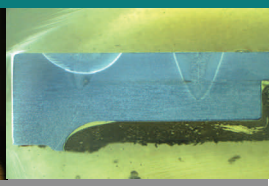

Industry Definitions

Bearing yield strength: The bearing stress at which a material exhibits a specified limiting deviation from the proportionality of bearing stress to bearing strain.

Bend radius: (1) The inside radius of a bent section. (2) The radius of a tool around which metal is bent during fabrication.

Bend test: A test for determining the relative ductility of metal that is to be formed (usually sheet, strip, plate, or wire) or for determining soundness and toughness of metal (after welding, for example). The specimen is usually bent over a specified diameter through a specified angle for a specified number of cycles. There are four general types of bend tests, named according to the manner in which the forces are applied to the specimen to make the bend.

Breaking load: The maximum load (or force) applied to a test specimen or structural member loaded to rupture.

Breaking stress: *See rupture stress.*

Brinelling: Damage to a solid bearing surface characterized by one or more plastically formed indentations brought about by overload. This term is often applied in the case of rolling element bearings.

Brittle crack propagation: A very sudden propagation of a crack with the absorption of no energy except that stored elastically in the body. Microscopic examination may reveal some deformation not noticeable to the unaided eye.

Brittle fracture: Separation of a solid accompanied by little or no macroscopic plastic deformation. Typically, brittle fracture occurs by rapid crack propagation with less expenditure of energy than for ductile fracture.

Buckling: A compression phenomenon that occurs when, after some critical level of load, a bulge, bend, bow, kink, or other wavy condition is produced in a beam, column, plate, bar, or sheet product form.

Cation: A positively charged atom or group of atoms, or a radical that moves to the negative pole (cathode) during electrolysis.

Caustic cracking: A form of stress corrosion cracking most frequently encountered in carbon steels or iron-chromium-nickel alloys that are exposed to concentrated hydroxide solutions at temperatures of 200 to 250 ° (400 to 480 ° F). Also known as caustic embrittlement.

Cavitation damage: Erosion of a solid surface through the formation and collapse of cavities in an adjacent liquid.

Cementite: A chemical compound of iron and carbon with a formula of Fe 3 C. This iron compound is hard and brittle because it contains about seven percent carbon.

Charpy test: An impact test in which a V-notched, keyhole-notched, or U-notched specimen, supported at both ends, is struck behind the notch by a striker mounted at the lower end of a bar that can swing as a pendulum. The energy that is absorbed in fracture.

Chelate: A coordination compound in which a heterocyclic ring is formed by a metal bound to two atoms of the associated ligands.

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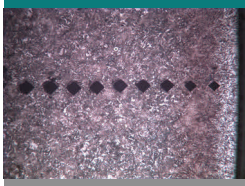
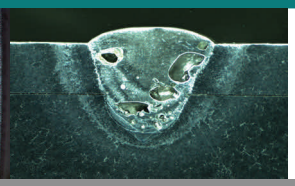
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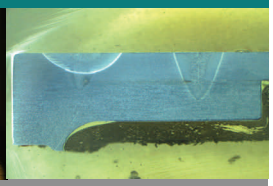

Industry Definitions

Chemical bonding: The joining together of atoms to form molecules.

Chevron pattern: A fractographic pattern of radial marks (shear ledges) that looks like nested letters "V"; sometimes called a herringbone pattern. Chevron patterns are typically found on brittle fracture surface in parts whose widths are considerably greater than their thicknesses. The points of the chevrons can be traced back to the fracture origin.

Chromatogram: The visual display of the progress of a separation achieved by chromatography. A chromatogram shows the response of a chromatographic detector as a function of time.

Chromatography: A separation method based on the distribution of sample compounds between the stationary phase and a mobile phase.

Cleavage fracture: A fracture, usually of a polycrystalline metal, in which most of the grains have failed by cleavage, resulting in bright reflecting facets. It is one type of crystalline fracture and is associated with low-energy brittle fracture.

Coefficient of friction, μ: The ratio of the force resisting tangential motion between two bodies to the normal force pressing these bodies together.

Compression test: A method for assessing the ability of a material to withstand compressive loads.

Compressive strength: Maximum compressive stress a material is capable of developing. With a brittle material that fails in compression by fracturing, the compressive strength has a ductile, malleable, or semi viscous materials (which do not fail in compression by a shattering fracture), the value obtained for compressive strength is an arbitrary value dependent on the degree of distortion that is regarded as effective failure of the material.

Compressive stress: A stress that causes an elastic body to deform (shorten) in the direction of the applied load. Contrast with *tensile stress*.

Constant life fatigue diagram: A plot (usually on rectangular coordinates) of a family of curves, each of which is for a single fatigue life (number of cycles), relating alternating stress, maximum stress, minimum stress, and mean stress. The constant life fatigue diagram is generally derived from a family of *S-N* curves, each of which represents a different stress ratio for a 50% probability of survival.

Corrosion fatigue: Cracking produced by the combined action of repeated or fluctuating stress and a corrosive environment at lower stress levels or fewer cycles than would be required in the absence of a corrosive environment.

Crack-extension force, *G*: The elastic energy per unit of new separation area that would be made available at the front of an ideal crack in an elastic solid during a virtual increment of forward crack extension. This definition is useful for either static cracks or running cracks. From past usage, crack extension force is commonly associated with linear-elastic methods of analysis.

Crack-extension resistance, *KR*: A measure of the resistance of a material to crack extension expressed in terms of the *stress-intensity factor*, the *crack-extension force*, or values of *J* derived using the *J-integral* concept.

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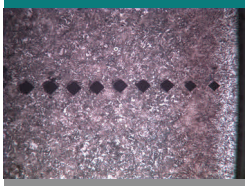
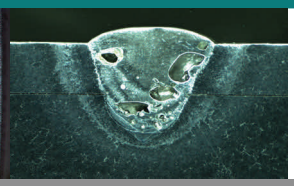
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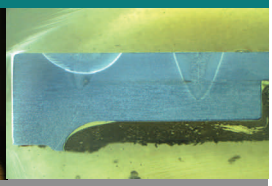

Industry Definitions

Crack length (depth), *a*: In fatigue and stress corrosion cracking, the *physical crack size*used to determine the crack growth rate and the *stress-intensity factor*. For the compact-type specimen, crack length is measured from the line connecting the bearing points of load application. For the center-cracked-tension specimen, crack length is measured from the perpendicular bisector of the central crack.

Creep: Time-dependent strain occurring under stress. The *creep strain* occurring at a diminishing rate is called primary or transient creep; that occurring at a minimum and almost constant rate, secondary or steady-rate creep; that occurring at an accelerating rate, tertiary creep.

Creep-rupture strength: The stress that will cause fracture in a creep test at a given time in a specified constant environment. Also known as stress-rupture strength.

Creep-rupture test: A test in which progressive specimen deformation and the time for rupture are both measured. In general, deformation is much greater than that developed during a creep test. Also known as stress-rupture test.

Creep strain: The time-dependent total strain (extension plus initial gage length) produced by applied stress during a creep test.

Creep stress: The constant load divided by the original cross-sectional area of the specimen.

Cup fracture (cup-and-cone fracture): A mixed-mode fracture, often seen in tensile test specimens of a ductile material, where the central portion undergoes plane-strain fracture and the surrounding region undergoes plane-stress fracture. One of the mating fracture surfaces looks like a miniature cup; it has a central depressed flat-face region surrounded by a shear lip. The other fracture surface looks like a miniature truncated cone.

Cycle: In fatigue, one complete sequence of values of applied load that is repeated periodically. The symbol *N* represents the number of cycles.

Cyclic loads: Loads that change value by following a regular repeating sequence of change.

Decarburization: Loss of carbon from the surface layer of a carbon-containing alloy due to reaction with one or more chemical substances in a medium that contacts the surface.

Deformation: A change in the form of a body due to stress, thermal change, change in moisture, or other causes. Measured in units of length.

Deformation bands: Parts of a crystal that have rotated differently during deformation to produce bands of varied orientation within individual grains.

Dendrite: A crystal that has a treelike branching pattern, being most evident in cast metals slowly cooled through the solidification range.

Density (of solids and liquids): The mass of a unit volume of a material at a specified temperature.

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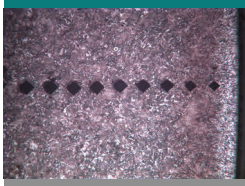
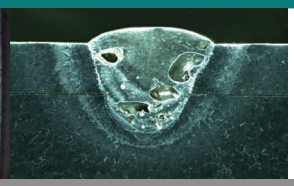
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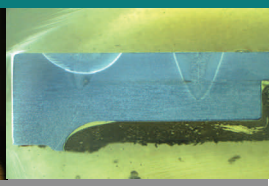

Industry Definitions

Dezincification: Corrosion in which zinc is selectively leached from zinc-containing alloys. Most commonly found in copper-zinc alloys containing less than 85% copper after extended service in water containing dissolved oxygen.

Diamond pyramid hardness test: See *Vickers hardness test*.

Dimple rupture: A fractographic term describing ductile fracture that occurs through the formation and coalescence of microvoids along the fracture path. The fracture surface of such a ductile fracture appears dimpled when observed at high magnification and usually is most clearly resolved when viewed in a scanning electron microscope. See also *ductile fracture*.

Discontinuous yielding: The nonuniform plastic flow of a metal exhibiting a yield point in which plastic deformation is inhomogeneously distributed along the gage length. Under some circumstances, it may occur in metals not exhibiting a distinct yield point, either at the onset of or during plastic flow.

Ductile fracture: Fracture characterized by tearing of metal accompanied by appreciable gross plastic deformation and expenditure of considerable energy.

Ductility: The ability of a material to deform plastically before fracturing. Measured by elongation or reduction in area in a tensile test, by height of cupping in a cupping test, or by the radius or angle of bend in a bend test.

Elastic deformation: A change in dimensions directly proportional to and in phase with an increase or decrease in applied force.

Elastic energy: The amount of energy required to deform a material within the elastic range of behavior, neglecting small heat losses due to internal friction. The energy absorbed by a specimen per unit volume of material contained within the gage length being tested. It is determined by measuring the area under the stress-strain curve up to a specified elastic strain.

Elastic limit: The maximum stress which a material is capable of sustaining without any permanent strain (deformation) remaining upon complete release of the stress.

Electrolyte: A chemical compound or mixture of compounds which when molten or in solution will conduct an electric current.

Elongation: A term used in mechanical testing to describe the amount of extension of a test piece when stressed.

Emission Spectrometer: An instrument that measures percent concentrations of elements in samples of metals and other materials; when the sample is vaporized by an electric spark or arc, the characteristic wavelengths of light emitted by each element are measured by a diffraction grating and an array of photodetectors.

Endurance limit: The maximum stress below which a material can presumably endure an infinite number of stress cycles. The value of the *maximum stress*, and the *stress ration* also should be state.

Engineering strain, e: A term sometimes used for average linear strain or conventional strain in order to differentiate it from *true strain*. In tension testing it is calculated by dividing the change in the gage length by the original gage length.

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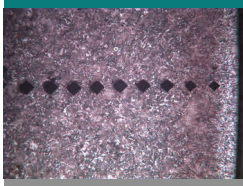
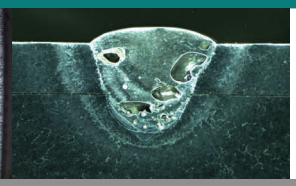
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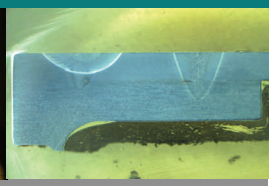

Industry Definitions

Engineering stress, s: A term sometimes used for conventional stress in order to differentiate it from true stress. In tension testing, it is calculated by dividing the breaking load applied to the specimen by the original cross-sectional area of the specimen.

Equiaxed grain structure: A structure in which the grains have approximately the same dimensions in all directions.

Erosion: Progressive loss of original material from a solid surface due to mechanical interaction between that surface and a fluid, a multicomponent fluid, or impinging liquid or solid particles.

Extensometer: An instrument for measuring changes in length over a given gage length caused by application or removal of a force. Commonly used in tension testing of metal specimens.

False Brinelling: Damage to a solid bearing surface characterized by indentations not caused by plastic deformation resulting from overload but thought to be due to other causes such as *fretting corrosion*.

Fatigue: The phenomenon leading to fracture under repeated or fluctuating stresses having a maximum value less than the ultimate tensile strength of the material. *Fatigue failure* generally occurs at loads which applied statically would produce little perceptible effect. Fatigue fractures are progressive, beginning as minute cracks that grow under the action of the fluctuating stress.

Fatigue life, N: The number of cycles of stress or strain of a specified character that a given specimen sustains before failure of a specified nature occurs.

Fatigue limit: The maximum stress that presumably leads to fatigue fracture in a specified number of stress cycles. The value of the *maximum stress*, and the *stress ratio*also should be stated.

Fatigue strength: The maximum stress that can be sustained for a specified number of cycles without failure, the stress being completely reversed within each cycle unless otherwise stated.

Fatigue striations: Parallel lines frequently observed in electron microscope fractographs or fatigue fracture surfaces. The lines are transverse to the direction of local crack propagation; the distance between successive lines represents the advance of the crack front during the one cycle of stress variation.

Fatigue test: A method for determining the range of alternating (fluctuating) stresses a material can withstand without failing.

Ferrite: A solid solution of carbon in body centered cubic (alpha) iron. It is soft and pliable and stable at room temperature.

Ferrite banding: Parallel bands of free ferrite aligned in the direction or working. Sometimes referred to as ferrite streaks.

Fibrous fracture: A gray and amorphous fracture that results when a metal is sufficiently ductile for the crystals to elongate before fracture occurs. When a fibrous fracture is obtained in an impact test, it may be regarded as definite evidence of toughness of the metal.

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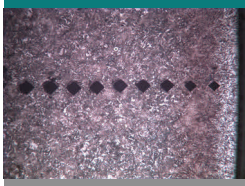
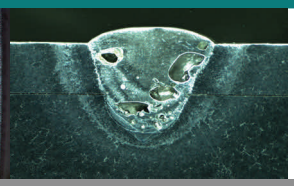
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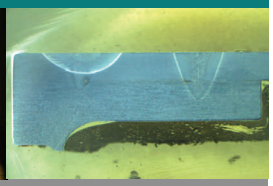

Industry Definitions

File hardness: Hardness as determined by the use of a file of standardized hardness on the assumption that a material that cannot be cut with the file is as hard as, or harder than, the file. Files covering a range of hardnesses may be employed.

Flexure: A term used in the study of strength of materials to indicate the property of a body, usually a rod or beam, to bend without fracture.

Flow lines: Texture showing the direction of metal flow during hot or cold working. Flow lines often can be revealed by etching the surface or a section of a metal part.

Fluorescence: A type of photoluminescence in which the time interval between the absorption and re-emission of light is very short.

Fractography: Descriptive explanation of a fracture process, especially in metals, with specific reference to photographs of the fracture surface. Macrofractography involves photographs at low magnification; microfractography, at high magnification.

Fracture: The irregular surface produced when a piece of metal is broken.

Fracture toughness: A generic term for measures of resistance to extension of a crack. The term is sometimes restricted to results of fracture mechanics tests, which are directly applicable in fracture control. However, the term commonly includes results from simple tests of notched or precracked specimens not based on fracture mechanics analysis. Results from tests of the latter type are often useful for fracture control, based on either service experience or empirical correlations with fracture mechanics tests.

Free Radical: Any molecule or atom that possesses an unpaired electron. In chemical notation, a free radical is symbolized by a single dot (to denote the odd electron) to the right of the chemical symbol.

Fretting: A type of wear that occurs between tight-fitting surfaces subjected to oscillation at very small amplitude. This type of wear can be a combination of *oxidative wear* and *abrasive wear*.

Fretting corrosion: The deterioration at the interface between contacting surfaces as the result of corrosion and slight oscillatory slip between the two surfaces.

Functional group: A chemical radical or structure that has characteristic properties: examples are hydroxyl and carboxyl groups.

Gage length: The original length of that portion of the specimen over which strain or change of length is determined.

Galling: A condition whereby excessive friction between high spots results in localized welding with subsequent spalling and a further roughening of the rubbing surfaces of one or both of two mating parts.

Gas Chromatography: A separation method involving passage of a gaseous mobile phase through a column containing a stationary absorbent phase; used principally as a quantitative analytical technique for volatile compounds.

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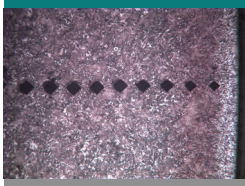
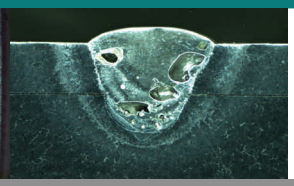
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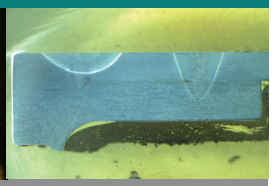

Industry Definitions

Grain growth: An increase in the average size of the grains in polycrystalline metal, usually as a result of heating at elevated temperature.

Grain size: A measure of the areas or volumes of grains in a polycrystalline material, usually expressed as an average when the individual sizes are fairly uniform. In metals containing two or more phases, the grain size refers to that of the matrix unless otherwise specified. Grain size is reported in terms of number of grains per unit area or volume, average diameter, or as a grain-size number derived from area measurements.

Granular fracture: A type of irregular surface produced when metal is broken that is characterized by a rough, grainlike appearance, rather than a smooth or fibrous one. It can be sub classified as transgranular or intergranular. This type of fracture is frequently called *crystalline fracture*; however, the inference that the metal broke because it "crystallized" is not justified, because all metals are crystalline when in the solid state.

Guided bend: The bend obtained by use of a plunger to force the specimen into a die in order to produce the desired contour of the outside and inside surfaces of the specimen.

Hardness: A measure of the resistance of a material to surface indentation or abrasion; may be thought of as a function of the stress required to produce some specified type of surface deformation. There is no absolute scale for hardness; therefore, to express hardness quantitatively, each type of test has its own scale of arbitrarily defined hardness. Indentation hardness can be measured by *Brinell, Rockwell, Vickers, Knoop, and Scleroscope hardness tests*.

Homogeneity: The degree of uniformity of composition or properties.

Hooke's Law: A material in which the stress is linearly proportional to strain is said to obey Hooke's law.

Hydrogen embrittlement: A condition of low ductility or hydrogen-induced cracking in metals resulting from the presence of hydrogen.

Hydrogen-induced delayed cracking: A term sometimes used to identify a form of hydrogen embrittlement in which a metal appears to fracture spontaneously under a steady stress less than the yield stress. There is usually a delay between the application of stress (or exposure of the stressed metal to hydrogen) and the onset of cracking.

Impact energy: The amount of energy required to fracture a material, usually measured by means of an *Izod test or Charpy test*. The type of specimen and test conditions affect the values and therefore should be specified.

Impact test: A test for determining the energy absorbed in fracturing a test piece at high velocity, as distinct from static test. The test may be carried out in tension, bending, or torsion, and the test bar may be notched or unnotched.

Indentation hardness: The resistance of a material to indentation as determined by hardness testing. The indenter, which may be spherical or diamond shaped, is pressed into the surface of a metal under specified load for a given time.

Inductively coupled plasma (ICP): An argon plasma excitation source for atomic emission spectroscopy or mass spectroscopy. It is operated at atmospheric pressure and sustained by inductive coupling to a radio-frequency electromagnetic field.

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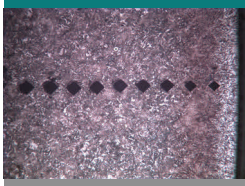
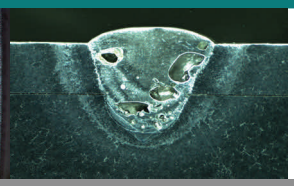
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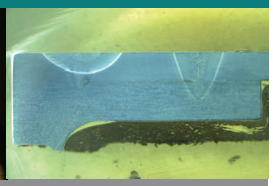

Industry Definitions

Infrared Spectrometer: A device used to measure the amplitude of electromagnetic radiation of wavelengths between visible light and microwaves.

Infrared Spectroscopy: The study of the interaction of material systems with electromagnetic radiation in the infrared region of the spectrum. The technique is useful for determining the molecular structure of organic and inorganic compounds by identifying the rotational and vibrational energy levels associated with the various molecules.

Infrared Spectrum: 1) The range of wavelengths of infrared radiation. 2) A display or graph of the intensity of infrared radiation emitted or absorbed by a material as a function of wavelength or some related parameter.

Ion: An atom, or group of atoms, which by loss or gain of one or more electrons has acquired an electric charge. If the ion is formed from an atom of Hydrogen or an atom of a metal, it is uaually positively charge; if the ion is formed from an atom of a nonmetal or from a group of atoms, it is usually negatively charged. The number of electronic charges carried by an ion is termed its electrovalence.

Ion Chromatography: An area of high performance liquid chromatography that uses ion exchange resins to separate various species of ions in solution and elute them to a suitable detector for analysis.

Ionic Bond: A type of chemical bonding in which one or more electrons are transferred completely from one atom to another, thus converting the neutral atoms into electrically charged ions. These ions are approximately spherical and attract each other because of their opposite charges.

Instrumented impact test: An impact test in which the load on the specimen is continually recorded as a function of time and/or specimen deflection prior to fracture.

Isotropy: A term indicating equal physical or mechanical properties in all directions within a material.

Izod test: A type of impact test in which a V-notched specimen, mounted vertically, is subjected to a sudden blow delivered by the weight at the end of a pendulum arm. The energy required to break off the free end is a measure of the impact strength or toughness of the material.

Knoop hardness test: An indentation hardness test using calibrated machines to force a rhomic-based pyramidal diamond indenter having specified edge angles, under specified conditions, into the surface of the material under test and to measure the long diagonal after removal of the load.

Ligand: The molecule, ion, or group bound to the central atom in a chelate or a coordination compound.

Liquid chromatography: A separation method based on the distribution of sample compounds between a stationary phase and a liquid mobile phase.

Load: In the case of testing machines, a force applied to a test piece that is measured in units such as pound-force, Newton, or kilogram-force.

Longitudinal direction: The principal direction of flow in a worked metal.

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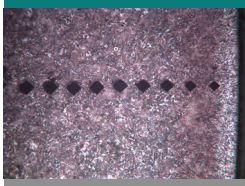
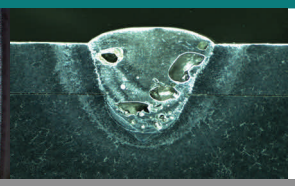
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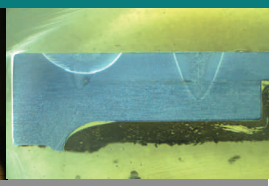

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Lüders lines: Elongated surface markings or depressions, often visible with the unaided eye, that form along the length of a tension specimen at an angle of approximately 45° to the loading axis. Caused by localized plastic deformation, they result from discontinuous (inhomogeneous) yielding. Also known as Lüders bands, Hartmann lines, Piobert lines, or stretcher strains.

Martensite: A generic term for microstructure formed by diffusionless phase transformation. In steel it is a body centered tetragonal structure with carbon atoms in the interstitial positions of the matrix. The structure is highly strained and is accordingly hard and brittle.

Mass Spectrometry: An analytical technique for identification of chemical structures, analysis of mixtures, and quantitative elemental analysis, based on application of the mass spectrometer.

Mass Spectrum.: A record, graph, or table that shows the relative number of ions of various masses that are producted when a given substance is processed in a mass spectrometer.

Maximum load, P max: (1) The load having the highest algebraic value in the load cycle. Tensile loads are considered positive and compressive loads negative. (2) Used to determine the strength of a structural member; the load that can be borne before failure is apparent.

Maximum stress, S max: The stress having the highest algebraic value in the stress cycle, tensile stress being considered positive and compressive stress negative. The *nominal stress* is used most commonly.

Mechanical properties: The properties of a material that reveal its elastic and inelastic behavior when force is applied or that involve the relationship between the intensity of the applied stress and the strain produced. The properties included under this heading are those that can be recorded by *mechanical testing*-for example, *modulus of elasticity, tensile strength, elongation, hardness, and fatigue limit*.

Metallography: The study of the structure of metals and alloys by various methods, especially by optical and electron microscopy.

Mechanical testing: The methods by which the *mechanical properties* of a metal are determined.

Microhardness: The hardness of a material as determined by forcing an indenter into the surface of a material under very light load; usually the indentations are so small that they must be measured with a microscope. Capable of determining hardnesses of different microconstituents within a structure, or of measuring steep hardness gradients such as those encountered in case hardening.

Microhardness test: A microindentation hardness test using a calibrated machine to force a diamond indenter of specific geometry, under a test load of 1 to 1000 gram-force, into the surface of the test material and to measure the diagonal or diagonals optically.

Modulus of elasticity, E: The measure of rigidity or stiffness of a metal; the ratio of stress, below the proportional limit, to the corresponding strain. In terms of the *stress-strain diagram*, the modulus of elasticity is the slope of the stress-strain curve in the range of linear proportionality of stress to strain. Also known as *Young's modulus*. For materials that do not conform to *Hooke's law* throughout the elastic range, the slope of either the tangent to the stress-strain curve at the origin or at low stress, the secant drawn from the origin to any specified point on the stress-strain curve, or the chord connecting any two specific points on the stress-strain curve is usually taken to be the modulus of elasticity. In these cases, the modulus is referred to as the *tangent modulus, secant modulus, or chord modulus*, respectively.

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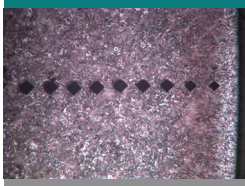
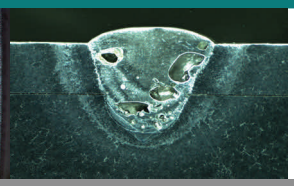
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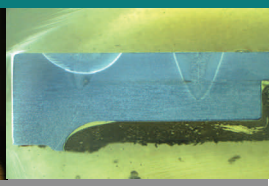

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Modulus of rupture: Nominal stress at fracture in a bend test or torsion test. In bending, modulus of rupture is the bending moment at fracture divided by the section modulus. In torsion, modulus of rupture is the torque at fracture divided by the polar section modulus.

Molecular Structure: The manner in which electrons and nuclei interact to form a molecule, as elucidated by quantum mechanics and the study of molecular spectra.

Molecule: A molecule may be thought of either as a structure built of atoms bound together by chemical forces as a structure in which two or more positively charged nuclei are maintained in some definite geometrical configuration by attractive forces from the surrounding cloud of electrons. Besides chemically stable molecules, short-lived molecular fragments termed free radicals can be observed under special circumstances.

Nebulizer: A device for converting a sample solution into a gas-liquid aerosol for atomic absorption, emission, and flourescence analysis. This may be combined with a burner to form a nebulizer burner.

Necking: (1) Reducing the cross-sectional area of metal in a localized area by stretching. (2) Reducing the diameter of a portion of the length of a cylindrical shell or tube.

Normality: A measure of the number of gram-equivalent weights of a compound per liter of solution.

Nuclear Magnetic Resonance: A phenomenon exhibited by a large number of atomic nuclei that is based on the existence of nuclear magnetic moments associated with quantized nuclear spins. These nuclear moments, when placed in a magnetic field, give rise to distinct nuclear Zeeman energy levels between spectroscopic transition can be induced by radio-frequency radiation. Plots of these transition frequencies, termed spectra, furnish important information about molecular structure and sample composition.

Objective: The primary magnifying system of a microscope. A system, generally of lenses, less frequently of mirrors, forming a real, inverted, and magnified image of the object.

Offset: The distance along the strain coordinate between the initial portion of a stress-strain curve and a parallel line that intersects the stress-strain curve at a value of stress (commonly 0.2%) that is used as a measure of the *yield strength*. Used for materials that have no obvious *yield point*.

Offset yield strength: The stress at which the strain exceeds by a specified amount (the offset) an extension of the initial proportional portion of the stress-strain curve. Expressed in force per unit area.

Orange peel: A surface roughening in the form of a pebble-grained pattern where a metal of unusually coarse grain is stressed beyond its elastic limit. Also known as pebbles and alligator skin.

Pearlite: A mixture of Ferrite and Cementite forming distinct layers or bands in slowly cooled carbon steels. The term is Pearlite is reference to its appearance under a microscope. The “mother of pearl” appearance is created by lamellar bands.

Photon: A particle representation of the electromagnetic field. The energy of the photon equals hv, where v is the frequency of the light in hertz, and h is Planck’s constant.

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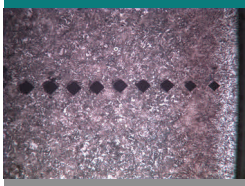
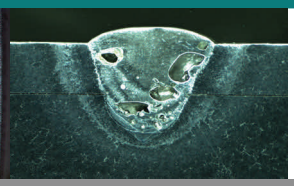
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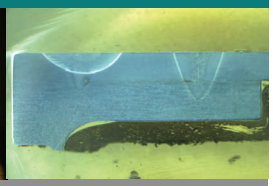

Industry Definitions

Physical properties: Properties of a metal or alloy the determination of which does not involve the deformation or destruction of the specimen-for example, density, electrical conductivity, coefficient of thermal expansion, magnetic permeability, and lattice parameter. Does not include chemical reactivity or properties more appropriately regarded as*mechanical properties*.

Physical testing: Methods used to determine the entire range of a material's *physical properties*. In addition to density and thermal, electrical, and magnetic properties, physical testing methods may be used to assess simple fundamental physical properties such as color, crystalline form, and melting point.

Pi bonding: Covalent bonding in which the atomic orbitals overlap along a plane perpendicular to the sigma bonds joining the nuclei of two or more atoms.

Pitting: In *tribology*, a type of wear characterized by the presence of surface cavities formed by processes such as fatigue, local adhesion, or cavitation.

Plane strain: The stress condition in linear elastic fracture mechanics in which there is zero strain in a direction normal to both the axis of applied tensile stress and the direction of crack growth (i.e. parallel to the crack front); most nearly achieved in loading thick plates along a direction parallel to the plate surface. Under plane-strain conditions, the plane of fracture instability is normal to the axis of the principal tensile stress.

Plane stress: The stress condition in linear elastic fracture mechanics in which the stress in the thickness direction is zero; most nearly achieved in loading very thin sheet along a direction parallel to the surface of the sheet. Under plane-stress conditions, the plane of fracture instability is inclined 45° to the axis of the principal tensile stress.

Plastic deformation: The permanent (inelastic) distortion of metals under applied stresses that strain the materials beyond its *elastic limit*.

Poisson's ratio, v: The absolute value of the ratio of transverse (lateral) strain to the corresponding axial strain resulting from uniformly distributed axial stress below the *proportional limit* of the material.

Proof stress: (1) The stress that will cause a specified small *permanent set* in a material. (2) A specified stress to be applied to a member or structure to indicate its ability to withstand service loads.

Proportional limit: The greatest stress a material is capable of developing without a deviation from straight-line proportionality between stress and strain.

Radial marks: Lines on a fracture surface that radiate from the fracture origin and are visible to the unaided eye or at low magnification. Radial lines result from the intersection and connection of brittle fractures propagating at different levels. Also known as shear ledges.

Radius of bend: The radius of the cylindrical surface of the pin or mandrel that comes in contact with the inside surface of the bend during bending. In the case of free or semi guided bends to 180° in which a shim or block is used, the radius of bend is one half the thickness of the shim or block.

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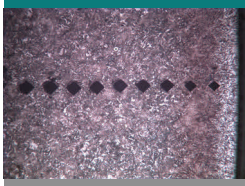
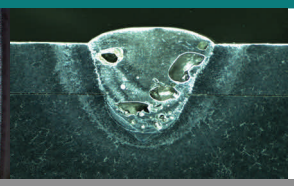
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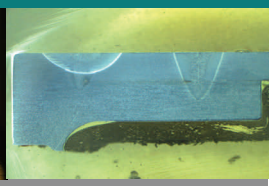

Industry Definitions

Ratchet marks: Lines on a fatigue fracture surface that result from the intersection and connection of fatigue fractures propagating from multiple origins. Ratchet marks are parallel to the overall direction of crack propagation and are visible to the unaided eye or at low magnification.

Reduction in area: The difference between the original cross-sectional area of a tensile specimen and the smallest area at or after fracture as specified for the material undergoing testing. Also known as reduction of area.

Residual stress: Stresses that remain within a body as the result of plastic deformation.

Retention Time: In chromatography, the amount of time a sample compound spends in the chromatographic column.

Rockwell hardness number, HR: A number derived from the net increase in the depth of impression as the load on an indenter is increased from a fixed minor load to a major load and then returned to the minor load. Rockwell hardness numbers are always quoted with a scale symbol representing the penetrator, load, and dial used.

Rockwell hardness test: An indentation hardness test using a calibrated machine that utilizes the depth of indentation, under constant load, as a measure of hardness. Either a 120° diamond cone with a slightly rounded point, or a 1/16- or 1/8-in.-diam. steel ball is used as the indenter.

Rockwell superficial hardness test: Same as *Rockwell hardness test*, except that smaller minor and major loads are used.

Rupture stress: The stress at failure. Also known as *breaking stress or fracture stress*.

Sample: One ore more units of product (or a relatively small quantity of a bulk material) that are withdrawn from a lot or process stream, and that are tested or inspected to provide information about the properties, dimensions, or other quality characteristics of the lot or process stream.

Scoring: In *tribology*, a severe form of wear characterized by the formation of extensive grooves and scratches in the direction of sliding.

Shear fracture: A ductile fracture in which a crystal (or a polycrystalline mass) has separated by sliding or tearing under the action of shear stresses.

Shear lip: A narrow, slanting ridge along the edge of a fracture surface. The term sometimes also denotes a narrow, often crescent-shaped, fibrous region at the edge of a fracture that is otherwise of the cleavage type, even though this fibrous region is in the same plane as the rest of the fracture surface.

Shear modulus, *G*: The ratio of shear stress to the corresponding shear strain for shear stresses below the proportional limit of the material. Values of shear modulus are usually determined by torsion testing. Also known as modulus of rigidity.

Shear strain: The tangent of the angular change, due to force, between two lines originally perpendicular to each other through a point in a body.

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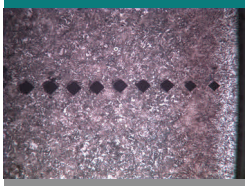
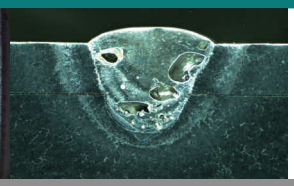
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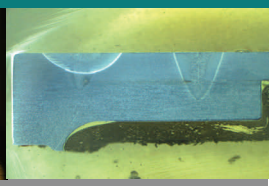

Industry Definitions

Shear strength: The maximum shear stress that a material is capable of sustaining. Shear strength is calculated from the maximum load during a shear or torsion test and is based on the original dimensions of the cross section of the specimen.

Shear stress: (1) A stress that exists when parallel planes in metal crystals slide across each other. (2) The stress component tangential to the plane on which the forces act. Also known as tangential stress.

Silky fracture: A metal fracture in which the broken metal surface has a fine texture, usually dull in appearance. Characteristic of tough and strong metals. Contrast with*crystalline fracture and granular fracture*.

Slip: Plastic deformation by the irreversible shear displacement (translation) of one part of a crystal relative to another in a definite crystallographic direction and usually on a specific crystallographic plane. Sometimes called glide.

Slip band: A group of parallel slip lines so closely spaced as to appear as a single line when observed under an optical microscope. See also *slip line*.

Slip line: The trace of the slip plane on the viewing surface; the trace is usually observable only if the surface has been polished before deformation. The usual observation on metal crystals (under the light microscope) is of a cluster of slip lines known as a slip band.

S-N curve.: A plot of stress, *S*, against the number of cycles to failure, *N*. The stress can be the maximum stress, Smax, or the alternating stress amplitude Sa. The stress values are usually nominal stresses; i.e., there is no adjustment for stress concentration. The diagram indicates the *S-N* relationship for a specified value of the mean stress, *Sm*, or the stress ration, A, or R and a specified probability of survival. For *N* a log scale is almost always used. For S a linear scale is used most often, but a log scale is sometimes used. Also known as *S-N* diagram.

Spalling: The cracking and flaking of particles out of a surface.

Specimen: A test object, often of standard dimensions or configuration that is used for destructive or nondestructive testing. One or more specimens may be cut from each unit of a sample.

Standard deviation: The most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Standard reference material: A reference material, the composition or properties of which are certified by a recognized standardizing agency or group.

Standardization: In analytical chemistry, the assignment of a compositional value to one standard on the basis of another standard.

Stationary Phase: In chromatography, a particulate material packed into the column or a coating on the inner walls of the column. A sample compound in the stationary phase is seperated from compounds moving through the column as a result of being in the mobile phase.

Stiffness: (1) The ability of a metal or shape to resist elastic deflection. (2) The rate of stress with respect to strain; the greater the stress required to produce a given strain, the stiffer the material is said to be.

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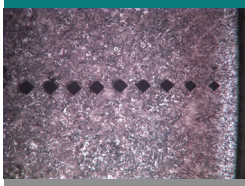
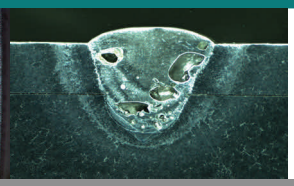
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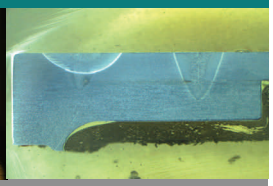

Industry Definitions

Strain-age embrittlement: A loss in ductility accompanied by an increase in hardness and strength that occurs when low-carbon steel (especially rimmed or capped steel) is aged following plastic deformation. The degree of embrittlement is a function of aging time and temperature, occurring in a matter of minutes at about 200° C (400° F), but requiring a few hours to a year at room temperature.

Strain aging: The changes in ductility, hardness, yield point, and tensile strength that occur when a metal or alloy that has been cold worked is stored for some time. In steel, strain aging is characterized by a loss of ductility and a corresponding increase in hardness, yield point, and tensile strength.

Strain hardening: An increase in hardness and strength caused by plastic deformation at temperatures below the recrystallization range. Also known as work hardening.

Strain rate: The time rate of straining for the usual tensile test. Strain as measured directly on the specimen gage length is used for determining strain rate. Because strain is dimensionless, the units of strain rate are reciprocal time.

Strength: The maximum nominal stress a material can sustain. Always qualified by the type of stress (tensile, compressive, or shear.)

Stress: The intensity of the internally distributed forces or components of forces that resist a change in the volume or shape of a material that is or has been subjected to external forces. Stress is expressed in force per unit area and is calculated on the basis of the original dimensions of the cross section of the specimen. Stress can be either direct (tension or compression) or shear.

Stress-corrosion cracking (SCC): A time-dependent process in which a metallurgically susceptible material fractures prematurely under conditions of simultaneous corrosion and sustained loading at lower stress levels than would be required in the absence of a corrosive environment. Tensile stress is required at the metal surface and may be a residual stress resulting from heat treatment or fabrication of the metal or the result of external loading. Cracking may be intergranular or transgranular, depending on the combination of alloy and environment.

Stress raisers: Changes in contour or discontinuities in structure that cause local increases in stress.

Stress-strain diagram: A graph in which corresponding values of stress and strain are plotted against each other. Values of stress are usually plotted vertically (ordinates or y axis) and values of strain horizontally (abscissas or x axis). Also known as deformation curve and stress-strain curve.

Striation: A fatigue fracture feature, often observed in electron micrographs, that indicates the position of the crack front after each succeeding cycle of stress. The distance between striations indicates the advance of the crack front across that crystal during one stress cycle, and a line normal to the striation indicates the direction of local crack propagation.

Temper brittleness: Brittleness that results when certain steels are held within, or are cooled slowly through, a certain range of temperature below the transformation range. The brittleness is manifested as an upward shift in ductile-to-brittle transition temperature, but only rarely produces a low value of reduction in area in a smooth-bar tension test of the embrittled material.

Tensile strength: In tensile testing, the ratio of maximum load to original cross-sectional area. Also known as ultimate strength.

Tensile stress: A stress that causes two parts of an elastic body, on either side of a typical stress plane, to pull apart. Contrast with *compressive stress*.

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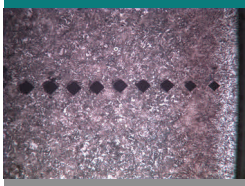
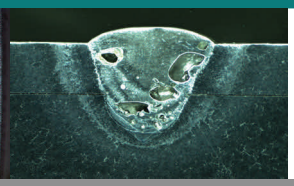
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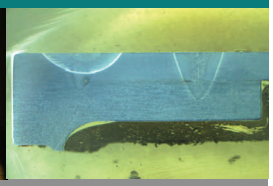

Industry Definitions

Tension: The force or load that produces elongation.

Tension testing: A method of determining the behavior of materials subjected to uniaxial loading, which tends to stretch the metal. A longitudinal specimen of known length and diameter is gripped at both ends and stretched at a slow, controlled rate until rupture occurs. Also known as tensile testing.

Thermocouple: A device for measuring temperature, consisting of lengths of two dissimilar metals or alloys that are electrically joined at one end and connected to a voltage-measuring instrument at the other end. When one junction is hotter than the other, a thermal electromotive force is produced that is roughly proportional to the difference in temperature between the hot and cold junctions.

Torsion: A twisting deformation of a solid body about an axis in which lines that were initially parallel to the axis become helices.

Toughness: The ability of a metal to absorb energy and deform plastically before fracturing.

Transition temperature: (1) An arbitrarily defined temperature that lies within the temperature range in which metal fracture characteristics (as usually determined by tests of notched specimens) change rapidly, such as from primarily fibrous (shear) to primarily crystalline (cleavage) fracture. (2) Sometimes used to denote an arbitrarily defined temperature within a range in which the ductility changes rapidly with temperature.

Transverse: Literally, “across,” usually signifiying a direction or plane perpendicular to the direction of working. In rolled plate or sheet, the direction across the width is often called long transverse, and the direction through the thickness, short transverse.

Tribology: The science and technology concerned with interacting surfaces in relative motion.

True strain: (1) The ratio of the change in dimension, resulting from a given load increment, to the magnitude of the dimension immediately prior to applying the load increment. (2) In a body subjected to axial force, the natural logarithm of the ratio of the gage length at the moment of observation to the original gage length. Also known as natural strain.

True stress: The value obtained by dividing the load applied to a member at a given instant by the cross-sectional area over which it acts.

Ultimate strength: The maximum stress (tensile, compressive, or shear) a material can sustain without fracture, determined by dividing maximum load by the original cross-sectional area of the specimen. Also known as nominal strength or maximum strength.

Vickers hardness test: An indentation hardness test employing a 136° diamond pyramid indenter (Vickers) and variable loads, enabling the use of one hardness scale for all ranges of hardness-from very soft lead to tungsten carbide. Also known as diamond pyramid hardness test.

Wear: Damage to a solid surface, generally involving progressive loss of material, due to relative motion between that surface and a contacting surface or substance.

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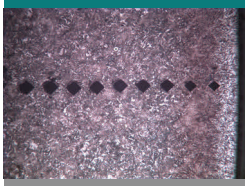
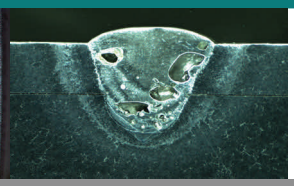
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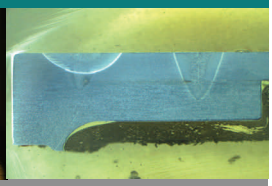

Industry Definitions

Widmanstätten structure: A structure characterized by a geometrical pattern resulting from the formation of a new phase along certain crystallographic planes of the parent solid solution. The orientation of the lattice in the new phase is related crystallographically to the orientation of the lattice in the parent phase. The structure is readily produced in many alloys by appropriate heat treatment.

Yield: Evidence of plastic deformation in structural materials. Also known as plastic flow or creep.

Yield point: The first stress in a material, usually less than the maximum attainable stress, at which an increase in strain occurs without an increase in stress. Only certain metals-those which exhibit a localized, heterogeneous type of transition from elastic to plastic deformation-produce a yield point. If there is a decrease in stress after yielding, a distinction may be made between upper and lower yield points. The load at which a sudden drop in the flow curve occurs is called the upper yield point. The constant load shown on the flow curve is the lower yield point.

Yield strength: The stress at which a material exhibits a specified deviation from proportionality of stress and strain. An offset of 0.2% is used for many metals. Compare with *tensile strength*.

Yield stress: The stress level of highly ductile materials, such as structural steels, at which large strains take place without further increase in stress.

Young's modulus: A term used synonymously with modulus of elasticity. The ratio of tensile or compressive stresses to the resulting strain.

Credit: 1985. Metals Handbook, Ninth Edition, Volume 8: Mechanical Testing. American Society for Metals: Metals Park, OH

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