

10.3 Glossary of Seal and Rubber Terms

— A —

- Abrasion:** The wearing away of a surface in service by mechanical action such as rubbing, scraping or erosion.
- Abrasion Resistance:** The ability of a rubber compound to resist mechanical wear.
- Absorption:** The physical mechanism by which one substance attracts and takes up another substance (liquid, gas, or vapor) into its INTERIOR.
- Accelerated Life Test:** Any set of test conditions designed to reproduce in a short time the deteriorating effect obtained under normal service conditions.
- Accelerated Service Test:** A service or bench test in which some service condition, such as speed, or temperature, or continuity of operation, is exaggerated in order to obtain a result in shorter time.
- Accelerator:** A substance which hastens the vulcanization of an elastomer causing it to take place in a shorter time or at a lower temperature.
- Acid Resistant:** Withstands the action of acids.
- Adhere:** To cling or stick together.
- Adhesion:** Tendency of rubber to bond or cling to a contact surface.
- Adsorption:** The physical mechanism by which one substance attracts another substance (either solid, liquid, gas, or vapor) to its SURFACE and through molecular forces causes the incident substance to adhere thereon.
- Aging:** To undergo changes in physical properties with age or lapse of time.
- Aging, Oxygen Bomb:** A means of accelerating the change in physical properties of rubber compounds by exposing them to the action of oxygen at an elevated temperature and pressure.
- Air Bomb:** Similar to an oxygen bomb but used with air. Used for accelerated aging test.
- Air Checks:** Surface markings or depressions due to trapping air between the material being cured and the mold or press surface.
- Air Curing:** The vulcanization of a rubber product in air as distinguished from vulcanizing in a press or steam vulcanizer.
- Alpha (α) Particles:** Positively charged particles composed of two protons and neutrons (often referred to simply as helium atom nuclei) and characterized by limited penetration.
- Ambient Temperature:** The surrounding temperature relative to a given point of application.
Note: Ambient temperature is not necessarily the same as atmospheric temperature.
- Aniline Point:** The lowest temperature at which equal volumes of pure, fresh aniline and an oil will completely dissolve in one another.

Antioxidant: An organic substance which inhibits or retards oxidation.

Antiozonant: A substance that retards or prevents the appearance of cracks from the action of ozone when the elastomer is exposed under tension, either statically or dynamically, to air containing ozone.

Antirad: A material which inhibits radiation damage.

Atmospheric Cracking: Cracks produced in surface of rubber articles by exposure to atmospheric conditions.

— B —

- Backrind:** Distortion at the parting line usually in the form of a ragged indentation.
- Back-Up Ring:** (Anti-extrusion device) a ring of relatively hard and tough material placed in the gland between the O-ring and groove side walls, to prevent extrusion of the O-ring.
- Bake-Out:** A process whereby a vacuum system is heated for a given time at some predetermined temperature to degas all the components, i.e. gauges, fittings, valves, seals, etc.
- Banbury Mixer:** A specific type of internal mixer used to blend fillers and other ingredients with an elastomer.
- Bench Test:** A modified service test in which the service conditions are approximated, but the equipment is conventional laboratory equipment and not necessarily identical with that in which the product will be employed.
- Beta (β) Particles:** Negatively charged particles or electrons, characterized by limited penetration.
- Bleeding:** Migration to the surface of plasticizers, waxes, or similar materials to form a film or beads.
- Blemish:** A mark, deformity, or injury that impairs the appearance.
- Blisters:** A raised spot in the surface or a separation between layers usually forming a void or air-filled space in the vulcanized article.
- Bloom:** A dusty or milky looking deposit that sometimes appears on the surface of an O-ring after molding and storage, caused by migration of a liquid or solid to the surface. Not to be confused with dust from external sources.
- Bond:** The term commonly used to denote the attachment of a given elastomer to some other member. Bonds may be classified by type as follows:
- Mechanical Bond — purely physical attachment accomplished by such means as “through” holes interlocking fingers, envelope design, riveting etc.
 - “Cold” Bond — adhesion of previously vulcanized elastomer to another member through use of suitable contact cements.
 - “Vulcanized” Bond — adhesion of an elastomer to a previously primed surface using heat and pressure thus vulcanizing the elastomer at the same time.
- Break:** A separation or discontinuity in any part of an article.
- Break-Out:** Force to initiate sliding. Expressed in same terms as friction. An excessive break-out value is taken as an indication of the development of adhesion.

Brittleness: Tendency to crack when deformed.

Buna-N: Same as *nitrile* rubber.

Buna-S: A general term for the copolymers of butadiene and styrene. Also known as SBR and GRS.

Butt Joint: Joining two ends of a seal whereby the junction is perpendicular to the mold parting line.

Butyl: A copolymer of isobutylene with small amounts of isoprene.

— C —

Calender: A machine used to form sheets of rubber between steel rollers.

Coefficient of Thermal Expansion: Average expansion per degree over a stated temperature range expressed as a fraction of initial dimension. May be linear or volumetric.

Cold Flexibility: Flexibility following exposure to a predetermined low temperature for a predetermined time.

Cold Flow: Continued deformation under stress.

Cold Resistant: Able to withstand the effects of cold or low temperatures without loss of serviceability.

Commercially Smooth: Degree of smoothness of the surface of an article that is acceptable for use.

Compound: A term applied to a mixture of polymers and other ingredients, to produce a usable rubber material.

Compression Modulus: The ratio of the compressive stress to the resulting compressive strain (the latter expressed as a fraction of the original height or thickness in the direction of the force). Compression modulus may be either static or dynamic.

Compression Set: The amount by which a rubber specimen fails to return to original shape after release of compressive load.

Conductive Rubber: A rubber capable of conducting electricity. Most generally applied to rubber products used to conduct static electricity.

Copolymer: A polymer consisting of two different monomers chemically combined.

Corrosion (Packing): Corrosion of rigid member (usually metal) where it contacts packing. The actual corroding agent is fluid medium trapped in the interface.

Corrosive (Packing): A property of packing whereby it is assumed often incorrectly, to promote corrosion of the rigid member by the trapped fluid.

Cracking: A sharp break or fissure in the surface. Generally due to excessive strain.

Creep: The progressive relaxation of a given rubber material while it is under stress. This relaxation eventually results in permanent deformation or “set.”

Cross-Section: A seal as viewed if cut at right angles to the mold parting line showing internal structure.

Cure: See Vulcanization.

Cure Date: Date when O-ring was molded; i.e., 2Q94 means second quarter 1994.

Curing Temperature: The temperature at which the rubber product is vulcanized.

Cylinder: Chamber in which piston, plunger, ram, rod, or shaft is driven by or against the system fluid.

— D —

Degassing: The intentional **but controlled** OUTGAS of a rubber substance or other material.

Diffusion: The mixing of two or more substances (solids, liquids, gases, or combinations thereof) due to the intermingling motion of their individual molecules. Gases diffuse more readily than liquids; similarly, liquids diffuse more readily than solids.

Durometer:

- (a) An instrument for measuring the hardness of rubber. Measures the resistance to the penetration of an indentor point into the surface of rubber.
- (b) Numerical scale of rubber hardness.

Dynamic: An application in which the seal is subject to movement, or moving parts contact the seal.

Dynamic Packing: A packing employed in a joint whose members are in relative motion.

Dynamic Seal: A seal required to prevent leakage past parts which are in relative motion.

— E —

Elasticity: The property of an article which tends to return it to its original shape after deformation.

Elastomer: Any synthetic or natural material with resilience or memory sufficient to return to its original shape after major or minor distortion.

Electron Volt: Unit of energy in atom calculations equal to 1.602 E^{-12} ergs.

Elongation: Generally means “ultimate elongation” or percent increase in original length of a specimen when it breaks.

ERG: Unit of energy (C.G.S.) equal to one dyne centimeter or approximately equal to the work done by a force of 1 gram causing a movement of 1 centimeter.

Evaporation: The direct conversion from liquid state to vapor state of a given fluid.

Explosive Decompression: Rupturing of the substructure caused by the rapid removal of pressure from an elastomer containing dissolved gases. The result is a blistering or swelling of the material. Some elastomeric compounds are quite resistant to explosive decompression.

Extrusion: Distortion or flow, under pressure, of portion of seal into clearance between mating metal parts.

— F —

Face Seal: A seal between two flat surfaces.

Filler: Chemically inert, finely divided material added to the elastomer to aid in processing and improve physical properties, i.e., abrasion resistance and strength — giving it varying degrees of hardness.

Flash: Excess rubber left around rubber part after molding due to space between mating mold surfaces; removed by trimming.

Flex Cracking: A surface cracking induced by repeated bending or flexing.

Flex Resistance: The relative ability of a rubber article to withstand dynamic bending stresses.

Flock: Fibrous filler sometimes used in rubber compounding.

Flow Cracks: Surface imperfections due to improper flow and failure of stock to knit or blend with itself during the molding operation.

Fluid: A liquid or a gas.

Friction: Resistance to motion due to the contact of surfaces.

Friction (Breakout): Friction developed during initial or starting motion.

Friction (Running): Constant friction developed during operation of a dynamic O-ring.

Fuel (Aromatic): Fuel which contains benzene or aromatic hydrocarbons. Causes high swell of rubber.

Fuel (Nonaromatic): Fuel which is composed of straight chain hydrocarbons. Causes little swell of rubber.

— G —

Gamma (γ) Radiation: Electromagnetic disturbance (photons) emanating from an atom nucleus. This type of radiation travels in wave form much like X-rays or light, but has a shorter wave length (approx. 1 \AA or $10 \text{ E-}07 \text{ mm}$). It is very penetrating.

Gasket: A device used to retain fluids under pressure or seal out foreign matter. Normally refers to a static seal.

Gland: Cavity into which O-ring is installed. Includes the groove and mating surface of second part which together confine the O-ring.

— H —

Hardness: Resistance to a distorting force. Measured by the relative resistance of the material to an indenter point of any one of a number of standard hardness testing instruments.

Hardness Shore A: The rubber durometer hardness as measured on a Shore "A" gauge. Higher numbers indicate harder material. 35 Shore "A" durometer reading is considered soft. 90 is considered hard.

Hermetic Seal: An airtight seal evidencing no detectable leakage.

Homogeneous:

- (a) General - a material of uniform composition throughout.
- (b) In seals - a rubber seal without fabric or metal reinforcement.

Hypalon: DuPont trade name for chlorosulphonated polyethylene, an elastomer.

— I —

Identification: Colored dots or stripes on seals for identification purposes.

Immediate Set: The deformation found by measurement immediately after removal of the load causing the deformation.

Immersion: Placing an article into a fluid, generally so it is completely covered.

Impact: The single, instantaneous stroke or contact of a moving body with another, either moving or at rest, such as a large lump of material dropping on a conveyor belt.

— L —

Leakage Rate: The rate at which a fluid (either gas or liquid) passes a barrier. Total Leakage Rate includes the amounts that diffuse or permeate through the material of the barrier as well as the amount that escapes around it.

Life Test: A laboratory procedure used to determine the amount and duration of resistance of an article to a specific set of destructive forces or conditions.

Linear Expansion: Expansion in any one linear dimension or the average of all linear dimensions.

Logy: Sluggish, low snap or recovery of a material.

Low Temperature Flexibility: The ability of a rubber product to be flexed, bent or bowed at low temperatures without cracking.

— M —

mm Hg: Millimeters of mercury. In vacuum work, this is a measure of absolute pressure, being the height of a column of mercury that the air or other gas will support. Standard atmospheric pressure will support a mercury column 760 millimeters high (760 mm Hg.) Any value less than this represents some degree of vacuum.

Memory: Tendency of a material to return to original shape after deformation.

Mirror Finish: A bright, polished surface.

Mismatch: Unsymmetrical seal caused by dissimilar cavities in mating mold sections.

Modulus: Tensile stress at a specified elongation. (Usually 100% elongation for elastomers).

Modulus of Elasticity: One of the several measurements of stiffness or resistance to deformation, but often incorrectly used to indicate specifically static tension modulus.

Mold Cavity: Hollow space or cavity in the mold which is used to impart the desired form to the product being molded.

Mold Finish: The uninterrupted surface produced by intimate contact of rubber with the surface of the mold at vulcanization.

Mold Lubricant: A material usually sprayed onto the mold cavity surface prior to the introduction of the uncured rubber, to facilitate the easy removal of the molded rubber parts.

Mold Marks: Indentations or ridges embossed into the skin of the molded product by irregularities in the mold cavity surface.

Mold Register: Accuracy of alignment or fit of mold sections.

Mooney Scorch: The measurement of the rate at which a rubber compound will cure or set up by means of the Mooney Viscometer test instrument.

Mooney Viscosity: The measurement of the plasticity or viscosity of an uncompounded or compounded, unvulcanized, elastomeric seal material by means of the Mooney Shearing Disk Viscometer.

— N —

Nitrile: (Buna-N) The most commonly used elastomer for O-rings because of its resistance to petroleum fluids, good physical properties and useful temperature range.

Nominal Dimension: Nearest fractional equivalent to actual decimal dimension.

Non-Blooming: The absence of bloom.

— O —

Occlusion:

- (a) The mechanical process by which vapors, gases, liquids, or solids are entrapped within the folds of a given substance during working or solidification.
- (b) The materials so trapped.

Off-Register: Misalignment of mold halves causing out-of-round O-ring cross section.

Oil Resistant: Ability of a vulcanized rubber to resist the swelling and deteriorating effects of various type oils.

Oil Swell: The change in volume of a rubber article due to absorption of oil or other or other fluid.

O-Ring: A torus; a circle of material with round cross section which effects a seal through squeeze and pressure.

O-Ring Seal: The combination of a gland and an O-ring providing a fluid-tight closure. (Some designs may permit momentary or minimum leakage.)

Moving (dynamic) — O-ring seal in which there is relative motion between some gland parts and the O-ring — oscillating, reciprocating, or rotary motion.

Non-moving (static) — O-ring seal in which there is no relative motion between any part of the gland and the O-ring (distortion from fluid pressure or swell from fluid immersion is excluded).

Optimum Cure: State of vulcanization at which the most desirable combination of properties is attained.

Outgassing: A vacuum phenomenon wherein a substance spontaneously releases volatile constituents in the form of vapors or gases. In rubber compounds, these constituents may include water vapor, plasticizers, air, inhibitors, etc.

Over Cure: A degree of cure greater than the optimum causing some desirable properties to be degraded.

Oxidation: The reaction of oxygen on a compound usual detected by a change in the appearance or feel of the surface, or by a change in physical properties or both.

Oxygen Bomb: A chamber capable of holding oxygen at an elevated pressure which can be heated to an elevated temperature. Used for an accelerated aging test.

Ozone Resistance: Ability to withstand the deteriorating effect of ozone (which generally causes cracking).

— P —

Packing: A flexible device used to retain fluids under pressure or seal out foreign matter. Normally refers to a dynamic seal.

Permanent Set: The deformation remaining after a specimen has been stressed in tension for a definite period and released for a definite period.

Permeability: The rate at which a liquid or gas under pressure passes through a solid material by diffusion and solution. In rubber terminology, it is the rate of gas flow expressed in atmospheric cubic centimeters per second through an elastomeric material one centimeter square and one centimeter thick (atm cc/cm²/cm sec).

Pit or Pock Mark: A circular depression, usually small.

Plasticizer: A substance, usually a viscous liquid, added to an elastomer to decrease stiffness, improve low temperature properties, and improve processing.

Plastometer: An instrument for measuring the plasticity of raw or unvulcanized compounded rubber.

Pock Mark: See "Pit or Pock Mark".

Polymer: A material formed by the joining together of many (poly) individual units (mer) of one or more monomers; synonymous with elastomer.

Porosity: Quality or state of being porous.

Post Cure: The second step in the vulcanization process for the more exotic elastomers. Provides stabilization of parts and drives off decomposition products resulting from the vulcanization process.

— R —

Radiation: An emission of varying energy content from a disturbed atom undergoing internal change. There are two broad classifications or types:

- (a) **Corpuscular**, comprising streams of **particles** either neutral or charged, e.g. protons, electrons, neutrons.
- (b) **Electromagnetic**, comprising **wave-like** emissions as gamma, ultraviolet, etc.

Radiation Damage: A measure of the loss in certain physical properties of organic substances such as elastomers, due principally to ionization of the long chain molecule. It is believed that this ionization process (i.e. electron loss) results in redundant cross-linking and possible scission of the molecule. This effect is **cumulative**.

Radiation Dosage: The total amount of radiation energy absorbed by a substance. This value is usually expressed in ergs per gram, and is denoted by the following units:

- (a) **Roentgen** - a quantity of gamma or X-ray radiation equal to approximately 83 ergs of absorbed energy per gram of air.

- (b) **REP** (Roentgen equivalent-physical) - a quantity of ionizing radiation that causes an energy absorption of approximately 83 to 93 ergs per gram of tissue.
- (c) **REM** (Roentgen equivalent-man)—similar to REP except used to denote biological effects.
- (d) **RAD** - the unit of dosage related to elastomers. It is independent of type of radiation or specimen, and denotes an energy absorption level of 100 ergs per gram (of elastomer). The RAD is approximately equal to 1.2 Roentgens.

Register, Off or Uneven: See Off-register.

Reinforcing Agent: Material dispersed in an elastomer to improve compression, shear or other stress properties.

Relative Humidity: The ratio of the quantity of water vapor actually present in the atmosphere to the greatest amount possible at the given temperature.

Resilient: Capable of returning to original size and shape after deformation.

Roentgen: See Radiation Dosage.

Rough Trim: Removal of superfluous material by pulling or picking. Usually the removal of a small portion of the flash or sprue which remains attached to the product.

Rubber: Same as elastomer.

Rubber, Natural: Raw or crude rubber obtained from plant sources.

Rubber, Synthetic: Manufactured or man-made elastomers.

Runout (Shaft): Same as gyration; when expressed in inches alone or accompanied by abbreviation "T.I.R." (total indicator reading), it refers to twice the radial distance between shaft axis and axis of rotation.

— S —

Scorching: Premature curing or setting up of raw compound during processing.

Seal: Any device used to prevent the passage of a fluid (gas or liquid).

Service: Operating conditions to be met.

Shaft: Reciprocating or rotating member usually within cylinder; not in contact with walls.

Shelf-Aging: The change in a material's properties which occurs in storage with time.

Shore A Hardness: See Hardness and Durometer.

Shrinkage: a) Decreased volume of seal, usually caused by extraction of soluble constituents by fluids followed by air drying. b) Difference between finished part dimensions and mold cavity used to make the part.

Silicone Rubber: Elastomer that retains good properties through extra wide temperature range.

Size, Actual: Actual dimensions of the O-ring or other seal, including tolerance limits.

Size, Nominal: Approximate size of part in fractional dimensions. May also indicate the actual size of the groove into which a nominal size seal fits.

Size Number: Number assigned to indicate inside and cross section diameters of an O-ring. Sizes established in SAE standard AS 568A have been adopted by the military and industry.

Sorption: The term used to denote the combination of absorption and adsorption processes in the same substance.

Specific Gravity: The ratio of the weight of a given substance to the weight of an equal volume of water at a specified temperature.

Sprue Marks: Marks left on the surface of a rubber part, usually elevated, after removal of the sprue or cured compound in the gate through which the compound is injected or transfer molded.

Squeeze: Cross section diametral compression of O-ring between surface of the groove bottom and surface of other mating metal part in the gland assembly.

Static Seal: Part designed to seal between parts having no relative motion. See Gasket.

Strain: Deflection due to a force.

Stress: Force per unit of original cross section area.

Sublimation: The direct conversion of a substance from solid state to vapor state without passing through a transitory liquid state. The vapor, upon recondensing, reforms into the solid state with no intervening liquid phase.

Sun Checking: Surface cracks, checks or crazing caused by exposure to direct or indirect sunlight.

Swell: Increased volume of a specimen caused by immersion in a fluid (usually a liquid).

— T —

Tear Resistance: Resistance to growth of a cut or nick when tension is applied to the cut specimen. Commonly expressed as pounds per inch thickness.

Temperature Range: Maximum and minimum temperature limits within which a seal compound will function in a given application.

Tensile Strength: Force in pounds per square inch required to cause the rupture of a specimen of a rubber material.

Terpolymer: A polymer consisting of three different monomers chemically combined.

Thermal Expansion: Expansion caused by increase in temperature. May be linear or volumetric.

Threshold: The maximum tolerance of an elastomer to radiation dosage expressed as a total number of ergs per gram (or rads) beyond which the physical properties are significantly degraded. This is generally an arbitrary value, depending on function and environment.

Torque: The turning force of a shaft.

Torr: The unit of pressure used in vacuum measurement. It is equal to 1/760 of a standard atmosphere, and for all practical purposes is equivalent to one millimeter of mercury (mm Hg).

Example:

25 mm Hg = 25 torr

1×10^{-3} mm Hg = 10^{-3} torr (millitorr)

1×10^{-6} mm Hg = 10^{-6} torr (microtorr)

Torsional Strength: Ability of rubber to withstand twisting.

TR-10: (10% Temperature retraction) A measure of the low temperature capability of an elastomer, being the temperature at which a stretched and frozen specimen has retracted by 10% of the stretched amount. (ASTM method D1329)

Trapped Air: Air which is trapped in a product or a mold during cure. Usually causes a loose ply or cover, or a surface mark, depression or void.

Trim: The process involving removal of mold flash.

Trim Cut: Damage to mold skin or finish by too close trimming.

— U —

Under-Cure: Degree of cure less than optimum. May be evidenced by tackiness, loginess, or inferior physical properties.

Ultimate Elongation: See Elongation.

— V —

Vacuum: The term denoting a given space that is occupied by a gas at less than atmospheric pressure. For degrees of vacuum; see vacuum level.

Vacuum Level: The term used to denote the degree of vacuum evidenced by its pressure in torr (or mm Hg).

- (a) **Rough** vacuum — 760 torr to 1 torr
- (b) Medium vacuum — 1 torr to 10^{-3} torr
- (c) High vacuum — 10^{-3} torr to 10^{-6} torr
- (d) Very high (hard) vacuum — 10^{-6} torr to 10^{-9} torr
- (e) Ultra **high** (ultra hard) vacuum — Below 10^{-9} torr

Vapor: The gaseous state of a fluid that normally exists as a liquid under atmospheric conditions, i.e. a gas whose temperature is below its critical temperature.

Vapor Pressure: The maximum pressure exerted by a liquid (or solid) heated to a given temperature in a closed container.

Virtual Leak: An “apparent” leak in a vacuum system that is traceable, in fact, to some internal (and often accidental) release of occluded and/or sorbed gases.

Example:

An undetected blister in a fused joint may eventually break down in a vacuum and suddenly (or slowly) release its entrapped air, thereby indicating a “leak.”

Viscosity: The property of fluids and plastic solids by which they resist an instantaneous change of shape, i.e., resistance to flow.

Void: The absence of material or an area devoid of materials where not intended.

Volatilization: The transition of either a liquid or a solid directly into the vapor state. In the case of a liquid, this transition is called evaporation, whereas in the case of a solid, it is termed sublimation.

Volume Change: A change in the volume of a seal as a result of immersion in a fluid expressed as a percentage of the original volume.

Volume Swell: Increase in physical size caused by the swelling action of a liquid.

Vulcanization: A thermo-setting reaction involving the use of heat and pressure, resulting in greatly increased strength and elasticity of rubber-like materials.

Vulcanizing Agent: A material which produces vulcanization of an elastomer.

— W —

Width: Seal cross section or thickness.

Wiper Ring: A ring employed to remove excess fluid, mud, etc., from a reciprocating member before it reaches the packings.