Glossary of Plastics Technology

Directions For Use

Entries without definitions are accompanied by page numbers that refer to places in the text where the terms are explained.

The asterix (*) indicates that the following word and its explanation is included in the glossary.

A

ABS P.31

Abbreviation for acrylonitrile-butadiene-styrene

ADDITIVES

Refers to a large group of materials and material systems that serve to influence specifically the processing and practical behavior of polymeric materials. It is not easy to distinguish among the various groups of additives but the following list will highlight some of them:

Internal and external lubricants (reduction in viscosity, lubricating effect). Antiblocking and separating agents (prevent adhesion among plastic materials).

*Initiators/activators, *inhibitors (polymerizing agents that start a reaction, speed it up, slow it down or stop it).

*Stabilizers, *antioxidants (work against damage and deterioration caused by heat, oxygen or ultraviolet rays).

Antistatic agents (reduce the electrical resistance of a plastic material which has the effect of working against the buildup of an electrical charge). Fireproofing agents.

*Fillers

*Softeners, plasticizers (make it more impact resistant).

Propellants (are used to provide for the creation of gases when manufacturing foam products).

Coloring agents (pigments).

AMINOPLASTICS P. 27

These thermosetting plastics are compounds of aldehyde with aminos or amidos. The most well-known aldehydes are the melamine formaldehyde resins (MF) and the urea formaldehyde resins (UF).

Both types have about the same properties, but the MF resins have somewhat better ratings for almost all of these characteristics. MF and UF plastics range from being translucent and colorless to light yellow and can be colored in light tones. They are resistant to light, have a low impact strength, are resistant to most of the organic solvents and have good electrical properties (resistance to surface leakage). MF plastics display better behavior than UF plastics in the face of heat (UF plastics are durable up to 176°F., 80°C., UF plastics up to 248°F., 120°C.), weathering, chemicals and moisture.

Areas of use: In plaster and binders, textile and paper coatings, in the manufacture of coatings, for molded and stamped parts, electrical insulation products and eating utensils.

AMORPHOUS STATE P. 68

"Formless", also: a vitreous state. Comparable to a liquid state with very high internal friction. Contrary to the situation for a material in a crystalline state, the atoms and molecules are not regularly arranged. Amorphous materials do not melt at a specific temperature but soften throughout a whole temperature range. Surfaces at points where the material has broken often display a characteristic shell-like appearance.

ANTIOXIDANTS

Agents that are added to batches of polymeric molding material to prevent deterioration. Their effectiveness is based upon the fact that they react more quickly with the oxygen than the polymer (to prevent aging).

Useful antioxidants are the aromatic aminos. They tend toward discoloration under the influence of light. The phenols, on the other hand, do not tend toward discoloration but are also not as powerful when used as antioxidants.

Examples of the use of antioxidants are in rubber and polyolefins.

AROMATICS P. 22

ASTM P. 74

American Society for Testing and Materials. Publishes standards for terminology, labelling, testing and production.

AZO METHOD P. 77

B

BAKELITE® P. 26

A trade name for different thermosetting plastics. Originally, this was the phenol-resin molded plastic developed by H. Baekeland at the beginning of this century. The patents for this product formed the basis for the manufacture of the fully synthetic materials that still dominated the market up to the middle of the current century.

BENDING (OF PIPES) P. 55

BENDING TEST

A materials test that serves to determine tensile strength and deformation characteristics when under a three-point stress. During the test the sample, which is lying upon two supports, is bent in the center at a constant rate of speed.

This test determines, among other things, the flexural strength ε_{bB} (the bending stress at the highest force) and the edge fiber ductility ε_{bB} at the highest force or ε_{bR} at the time of failure.

BREAKDOWN, CHEMICAL P. 54

Also: chemical deterioration)

BREAKDOWN, THERMAL P. 54

(Also: thermal deterioration)

C

CALIBRATION MECHANISM P. 74

CASEIN PLASTICS P. 26

CATALYST P. 61

A material that, even when present in small amounts, produces a chemical reaction or accelerates it, without actually taking part in that reaction.

CELLULOID P. 26

* Cellulose nitrate

CELLULOSE NITRATE (CN)

Manufactured by treating cellulose, a material gained from plants, with a mixture made of saltpeter and sulfuric acid. When they are converted to esters, the OH groups react partially or completely with the acid and as a result create nitrates.

Depending upon the degree of conversion to esters (nitrogen content), the material has different characteristics and usages. Over 13% nitrogen (a complete conversion would be 14.2%) produces a material that burns explosively (gun cotton). At 12% content there are ester-soluble types that are used for producing varnishes and lacquers. At about 11% nitrogen content, it is used as molding material. With about 30% camphor oil added as a softener, it is used to produce celluloid. Celluloid is the oldest thermoplastic that was produced in amounts worth mentioning. It was used over 100 years ago as a substitute for ivory in billiard balls.

Cellulose nitrate is characterized by its resistance to abrasion and by its extraordinary toughness. In many cases there are decisive disadvantages. It catches on fire easily and is sensitive to ultraviolet rays. It turns yellow and becomes brittle in sunlight. Because of these disadvantages, it has only limited usage. Because of its durability and its low tendency toward static-electricity buildup, it is quite suitable for film. It is also of some importance in the production of varnishes, glues, combs, toothbrushes, eyeglass frames and similar articles.

CN

Abbreviation for * cellulose nitrate.

COLD, RESISTANCE TO

Refers to the strength of a polymeric material at low temperatures. The mechanical characteristics of plastics are dependent upon the temperature. When the temperature is lower, they tend to become more brittle and fragile. Tensile strength and impact strength are lowered. Resistance to cold is especially important for elastomers (rubber).

COPOLYMERS

Also called mixed polymers. They are made up of two or more different, regularly occurring monomers. Copolymers that are made up of three or more different monomers are called terpolymers. Copolymers occur for the most part in three different types: 1) statistical copolymers with a specific calculable distribution of the elements; 2) block copolymers in which whole rows of the particular elements change off with each other and 3) grafted copolymers in which side chains of the one monomer are "grafted" onto the other monomer.

Copolymerization serves the purpose of bringing about an intentional change in the characteristics of a *homopolymer. It is used in this way in the case of polymers based on propylene, styrene or vinyl chloride. Some examples of such products are synthetic rubber such as ethylene-propylene rubber, fluororubber, nitrile rubber or styrene-butadiene rubber.

COPPER BRITTLENESS P. 26

CRACKING P. 22

CREEP P. 79

Slow, for the most part irreversible, change in the shape of a plastic product that is subjected to a constant, long-term stress. It is covered by the time-to-failure tensile test as described in ASTM D2990. This test results in the time-to-failure graph (σ over t) and the so-called creep curve (ε over t).

If enough stress is applied, rupture (creep rupture) can occur. When under stress for a very long time, the rupture limit can be much lower than it would be for a tensile test conducted on unstressed tubing of the same kind.

The tendency toward creep is different depending upon the material involved. As the molecular weight of a material increases and the *molecular weight distribution is closer, the rate of creep diminishes. Reinforcing fillers (such as fiberglass) decrease the tendency toward creeping. Softeners increase it.

CROSS-LINKING P. 74

A chemical process (or its outcome) that creates a three dimensional network through the linking of molecule chains. The polymers that are otherwise capable of being melted and dissolved in certain agents become incapable of being melted and indissoluble through the effects of cross-linking.

Examples of cross-linking are the hardening of thermosetting plastics, the vulcanization of rubber, the cross-linking of PE with peroxide (because of the fact that PE has a rubber-like elasticity above its crystalline melting point), the cross-linking done through energy-rich rays and, in some cases, through aging.

The degree of cross-linking in a material can be determined from the E-modulus or by soaking the material in a solvent.

CROSS-LINKING AGENT

*Surfactants

CROSS-LINKING BY RADIATION P. 77

CROSS-LINKING METHODS P. 74

CRUDE OIL P. 22

CRYSTALLINITY

A polymer is considered to have a crystalline structure if it is, for the most part, both spatially and chemically regular.

Relatively simple chain molecules without large side groups, such as PA, PE and polyesters can usually crystallize quite well.

What is expressed as the crystallinity of a material is the percentage of the crystalline portion in a particular mass of the material. The crystallinity of certain symmetrically structured polymers can be quite high. In the case of olefins, such as some types of HDPE, it can be as high as 90%.

D

DENSITY P. 68

The mass of a material per unit of volume expressed in lbs/ft^3 or Mg/m^3. When speaking

of density as it refers to the compact state of a material, a distinction must be made between raw density (volume including hollow space) and bulk density (volume including interspace and if present, hollow space).

DETERGENTS

Synthetic *surfactants with a washing and cleaning effect.

DIFFUSION

A penetration process that is based upon the tendency of gas and liquid molecules to spread out into the entire area that is available even in solid materials. A related process, the movement of substances through solid plastics, is permeation. It takes place in three stages, absorption (assimilation), diffusion and desorption (elimination).

DIMENSIONAL CHANGE TEST P. 74

DIN

The abbreviation for the German Institute of Standards (Deutsches Institut fuer Normung e. V.). Acronym: DIN. The institute, through its committees and staff members, revises the German books of standards (known as the DIN standards).

DISTILLATION (OF CRUDE OIL) P. 22

DUCTILE RUPTURE P. 54

DVGW P. 57

The German Gas and Water Specialists Association (Deutscher Verein für Gas- und Wasserfachleute).

E

EBONY P. 26

ELASTICITY

A property that refers to the ability of a material to return to its original shape after the removal of an external force. The unit used to rate materials according to this characteristic is called the *elasticity modulus (also: Young's modulus). A material's elastic behavior is to be contrasted with its *plasticity.

ELASTICITY MODULUS (E) P. 44

Also referred to as Young's modulus. A constant relationship of stress (σ) to change in length (ε) in the area of a substance's elasticity ($E = \sigma/\varepsilon$). In the case of nonlinear, stresselongation behavior, there is a distinction made between a tangential and secant modulus.

ELASTOMER

A loosely cross-linked, large-moleculed material that, through the use of very little force, can be stretched to at least double its original length and, after the force is removed, will return quite quickly to its original form.

ELONGATION P. 44

E-MODULUS

*Elasticity modulus.

ENGEL METHOD P. 68

A method of manufacturing hollow-shaped products from PE molding materials by sintering (fusing). It has become important as a method of cross-linking.

EPOXY RESIN P. 27

EROSIVE CORROSION P. 64

ESTER

A compound of nonorganic or organic acids with alcohol. Water is split off when it is created.

ETHYLENE

The most simple hydrocarbon ($H_2C = CH_2$). It is a colorless and almost odorless gas. Its boiling point is about -157°F. (-105°C.). It is produced industrially through the cracking process from crude oil. It is then processed to produce the polymers *polyethylene and *polystyrene and their copolymers.

ETHYLENE-PROPYLENE RUBBER

This material is divided into two groups, ethylene-propylene copolymers and ethylene-propylene terpolymers.

The copolymerization of propylene with ethylene improves the impact resistance of polypropylene at low temperatures. As the ethylene content increases, copolymers with rubberlike elasticity are produced.

Through the use of a third monomer, a vulcanized terpolymer is created (synthetic rubber EPDM).

EXCESS TEMPERATURE P. 42

EXTRAPOLATION (OF CURVES) P. 54

EXTRUDER

A machine used primarily for continuous forming of products and especially those made of thermoplastic materials.

Machine types: Piston extruder and one- or multiple-screw extruder.

Purposes: Preparation of materials through mixing, measuring and combining additives, removal or addition of gases, homogenization, plasticization, polymerization, cross-linking and similar tasks, shaping the extruded material into solid, hollow and cellular profiles, into pipes and tubing, coverings, thread (monofilament), bars, foils and coverings and hollow products (blow extrusion). In certain cases, the extruder is used to convey it along and to carry it out.

Mode of operation: The material in the form of granules or powder is placed into the filling equipment on the back side of the extruder and is carried along by an auger into the cylinder. There it is melted and plasticized under compression by heat from friction or some other source. The auger or screw then builds up the pressure to that necessary for pressing the material through the die. This procedure produces the desired shape. Then it is cooled off.

*Plasticization is a complicated procedure that is affected by a large number of factors including temperature, pressure, number of turns, turning direction, construction of the auger, and composition of the material that is to be molded. During plasticization and extrusion, the molecular chains are, to a certain extent, axially aligned. When they are cooled, they retain this position.

EXTRUSION

A method used for the continuous formation of tubing and hoses from plastic materials. The machines themselves are known as *extruders. Depending upon the methods and the materials, the machine could be a single- or multiple-screw extruder and a single- or double-piston extruder (Engel method).

The material is first converted to a flowing consistency, is pressed through a ring-shaped tubing die and goes from there into the calibration stage where the tubing is given its exact planned diameter and is hardened. The calibrating equipment consists of, for example, a cooled calibration pipe or drawing dies in a water bath. The tubing is pressed onto the calibration tool through the use of internal pressure or by the vacuum effect around it. The finished tubing is then cut off or coiled.

EXTRUSION PRESS

*Extruder

F

FILLERS

*Additives. Additional materials that are used along with the original molding material. The main purpose of fillers is to make the material go further and, in that way, to reduce the cost of product. The actual properties of the material are either retained or, in some cases, even improved.

Fillers are solids (powdered, layered or fibered) with particles that are usually under 1 µm in size. They are used mainly with thermosetting plastics. In some cases, the additives can even wiegh more than the actual plastic resin. The resin carriers that are used in compression-molded materials are not considered to be additives in this sense.

FOAM

Also known as foam plastic, it is a light material made of synthetic materials. It contains open (interconnected) or closed hollow areas (cells). These are formed by the introduction of gases or catalysts (gas creation).

G

GEL

A cross-linked polymer that has swelled up vigorously in a solvent is a gel. If a cross-linked molecule extends over the total volume of a reaction container, but the cross-linked product is still swollen by solvent, it is known as a gel.

GOODYEAR, CHARLES P. 26

GRANULES

Pellets of about the same size and shape. This is a common form in which synthetic resins are supplied.

H

HAMMERING P. 64

HDPE

Abbreviation for high-density polyethylene (hard PE). *Polyethylene

HEALTH CLEARANCE P. 50

HOMOGENEITY P. 68

HOMOPOLYMERS

Polymers that are made up of only one monomer. Opposite: *Copolymers. Many thermoplastic materials are homopolymers (PB, PE, PS).

HYATT, JOHN P. 26

HOOP STRESS P. 53

I

IMPACT TEST

This is a materials test that investigates the resistance to breaking or change in shape under the force of an impact. Impact resistance is measured as the energy that is required to destroy (with a pendulum) a sample of a specified size (unit = ft – lb/in^2 or kj/m^2).

When determining the notch-impact strength, the sample is notched.

The impact resistance of a thermoplast can be increased by the addition of softeners. That of thermosets can be improved through the use of reinforcing fillers (for example, glass fibers) or through a decrease in the amount of cross-linking (hardening).

INHIBITORS

*Additives that slow down a chemical reaction or stop it altogether. For example, they prevent premature hardening. They also raise the storage life and stability of semimanufactured products.

INITIATORS

Also: activators, reagents, accelerators. *Additives that start a chemical reaction or allow it to proceed more rapidly. In most cases, they become a component of the final product.

ISO P. 54

Abbreviation of the International Organization for Standardization. The location of the general secretariat of the organization is Geneva.

ISOTACTIC POLYMERS

*Tacticity

L

LABELLING P. 50

LDPE

Abbreviation for low-density polyethylene (soft PE). *Polyethylene.

LONG-TERM TESTING P. 52

M

MACROMOLECULES P. 27

Molecules that are made up of a very large number of atoms. They are the components of polymeric materials. Macromolecules are built up synthetically from simple basic molecules (monomers). They can be divided into chain molecules and spherical molecules.

MDPE

Abbreviation for medium-density polyethylene. *Polyethylene.

MELTING INDEX (g/10 min) P. 68

This is a measurement of the flowability and so also of the workability of a plastic. It is presented in terms of grams of a material that can be pressed out in ten minutes under standardized conditions (temperature, pressure, nozzle shape). It is dependent upon the molecular weight of the polymer. It is of importance above all in the case of the polyolefins.

MER

Theoretically the smallest building block in a macromolecular chain. Unlike a monomer, it does not represent an actually existing material.

METAL DEACTIVATORS P. 61

METHYLENE CHLORIDE P. 56

MF

Abbreviation for melamine-formaldehyde resin. *Aminoplastics.

MOLDED PARTS

Products made from molding material in enclosed molds (compression parts, injection parts).

MOLDING MATERIAL

Any *synthetic resin that is prepared with *additives and readied for processing into plastic products under pressure and heat using a variety of methods such as injection molding, compression molding, extrusion or blow molding.

MOLECULAR WEIGHT P. 68

The sum of the atomic weights of all the atoms that make up a molecule. Polymeric material does not have a uniform molecular weight, but rather an average weight, that can be arrived at from the molecular weight distribution.

MOLECULAR WEIGHT DISTRIBUTION

The molecular chains in polymeric materials are not uniform in length. That is why it is not possible to provide a uniform molecular weight but rather only an average molecular weight (median molecular weight). This nonuniformity is reflected in the molecular weight distribution. Two polymers of the same type with the same average molecular weight can have a different molecular weight distribution and so also different properties. When the molecular weight distribution is broad, the lengths of the molecular chains can vary greatly.

MONOMERS

These are substances with a relatively low molecular weight whose molecules have the ability to build chainlike macromolecules (*polymers) through reactions with themselves or with other monomers. Typical monomers are substances with a double bond between two carbon atoms, vinylmonomers, olefins or substances with two, usually conjugated, (—C=C—C=C—) double bonds.

MONOSIL METHOD P. 77

N

NAPTHENE P. 22

NYLON (PA)

Originally a brand name for PA6.6 fibers and threads of the American manufacturer, DuPont. In English speaking countries today, nylon is used as a general term for *PA.

O

OLEFINS

Unsaturated hydrocarbon substances (with a double bond). The most important building blocks (*monomers) of the *polyolefins are *ethylene, propylene, butylene-1 and others.

OXIDATION P. 54

OXYGEN DIFFUSION P.46

P

PA

Abbreviation for *polyamides

PARAFFINS P. 22

PB

Abbreviation for *polybutylene-1.

PBTP

Abbreviation for polybutyleneterephthalate. *Polyester, saturated.

PC

Abbreviation for *polycarbonate.

PE

Abbreviation for *polyethylene.

PENETRABILITY

The property of a material that refers to the penetration of gases and vapor through a solid substance. In the plastics field it is of interest for pipes, sealants, foils and the like. As a measurement, it is presented as the amount that penetrates a certain wall thickness at a specific pressure during a specific period of time. *Diffusion.

PERMEABILITY

*Penetrability

PERMEATION

*Diffusion

PEROXIDE P. 68

A substance with the structure —O—O—. It exists as organic and inorganic peroxide. It plays an important role as a *catalyzer and *initiator during the polymerization and cross-linking process.

PEROXIDE CROSS-LINKING METHODS P. 77

PETP

Abbreviation for polyethyleneterephthalate. *Polyester, saturated.

PEX

Another abbreviation for cross-linked polyethylene, *XLPE. ASTM Standards for PEX are F876 and F877.

PHENOLS

Compounds derived from a compound of benzol (an annular hydrocarbon substance) with one or more of the OH groups. It is made of coal tar but is usually produced synthetically. It is an important preliminary product in the manufacture of synthetic resins. *Phenoplastics.

PHENOPLASTICS P. 27

A group of thermosetting plastics that originate from the condensation reaction between phenols and aldehydes.

The most important types by far are the phenol formaldehyde resins. They belong to the "classic" plastics and were already introduced at the beginning of this century under the name "Bakelite".

Their uses are exceptionally diverse: varnishes, glues, impregnating agents, binding agents, in the manufacture of plywood, in the production of laminates, for casting molds and cores and as abrasives. Together with *fillers and resin carriers they are processed into insulation products, housings for equipment, handles, bearings, molded products and various other items.

pH VALUE P. 36

PILOT PLANT P. 70

PLASTICITY

Thermoplastic fluidity. A property of a material that refers to its ability to change its form irreversibly under the influence of a force without afterwards returning to its original form. It is contrasted with *elasticity.

PLASTICIZE

An initial phase in the processing of plastic products in which a molding material is transformed by thermal and mechanical means into a fluid, that is, made plastic or capable of being molded as, for example, is done in an extruder.

PO

Abbreviation for *polyolefin.

POLYAMIDES (PA) P. 27

Thermoplastic, synthetic materials that are, for the most part, designated by an additional number which indicates the number of the carbon atoms in their monomers. (For example, the fiber PA6.6 is known as Nylon.)

Polyamides have outstanding mechanical properties. A high degree of toughness, a low fatigue-failure rate, a small degree of creep, resistance to abrasion and a low friction coefficient open them up to a broad area of uses. Processing is mainly by injection molding. They provide the material for fibers and monofilaments. They are insensitive to most organic solvents.

A disadvantage is the very high water-absorption rate. Water absorbtion has a softening effect and so changes the material's measurements and certain other properties. For that reason, polyamides have not been widely used in the electromechanical fields.

POLYBUTYLENE-1 (PB)

This is a thermoplastic, isotactic polymer that is relatively highly crystallized. Its manufacturing process is similar to PP. Its characteristics are similar to LDPE but it has a greater impact strength and heat resistance.

PB has a melting point of 257° to 266°F. (125° to 130°C.) with a density of about 56.5 lb/ft° (0.91 Mg/m°). Upon melting, it is transformed into a low-crystalline, unstable material. It contracts and reverts back to its original stable state after a few days.

Uses: Tubing, wire insulation.

POLYCARBONATE (PC)

A thermoplastic material that, chemically, is a polyester consisting of carbonic acid and bisphenol A.

It has a high mechanical strength and is impact resistant even at low temperatures (to −40°F. or −40°C.). It is resistant to heat, holds its shape well and has very good electrical qualities. It also has a low water-absorption rate, is transparent and is sensitive to predetermined breaking points (microcracks and scratches).

POLYCARBONATE ROD P. 56

POLYCONDENSATION

Chemical reactions that take place when polymers are formed. Various types of molecular components join together while giving off water to form materials consisting of large molecules.

POLYESTERS, SATURATED

Also known as thermoplastic polyesters, they are partially crystallized products of esterization (primarily of terephthalic acid). Two of

the most important materials of this group are of that sort: polybutyleneterephthalate (PBTP) and polyethyleneterephthalate (PETP).

They are stiff, hard plastics. The melting points are 428°F. (220°C.) for PBTP and 491°F. (255°C.) for PETP. They are resistant to heat and ultraviolet rays, are naturally stable, have a low friction coefficient, have good electrical qualities even in high humidity and temperatures, and have a low impact strength.

Uses: Precision injection molding articles, cloth fibers, tools.

POLYESTERS, UNSATURATED (UP)

These thermosetting plastics are linear polyesters that are built up from the esterization with glycols (alcohols). Their molecular structure is kept static through the use of various components. By mixing them with reaction retardants, the UP resins, which are for the most part clear as water, can be stored for long periods of time. Cross-linking polymerization begins only after the addition of a hardening agent.

UP is, for all practical purposes, insoluble, insensitive to water and resistant to heat from 176° to 284°F. (80° to 140°C.). It has very good electrical qualities.

UP resins have achieved a substantial degree of importance in the technology of fiberglass-reinforced plastics.

Uses: In the boat-building, automobile-body and container industries. Also used for tubing.

POLYETHYLENE (PE)

A thermoplastic of the *polyolefin group, it is a polymer of *ethylene. The two main methods used to manufacture polyethylene (high pressure, low pressure) produce final products that have somewhat different characteristics.

The high-pressure method polymerizes ethylene at high pressures (14,500 to 43,500 psi or 100 to 300 MPa) and at relatively high temperatures (176° to 572°F. or 80° to 300°C.). The end product of this method is high-pressure polyethylene, known mainly as low-density polyethylene (LDPE). Density: from 56.4 to 58.3 lb/ft^3 (0.91 to 0.94 Mg/m^3). Crystallinity: 50% to 80%. Melting point: 221° to 257°F. (105° to 125°C.).

The low-pressure method polymerizes at low pressures (14.5 to 5800 psi or 0.1 to 40 MPa) and at moderate temperatures (140° to 518°F. or 60° to 270°C.) in a solvent and along with heterogenous catalyzing agents. The end-product of this method is low-pressure polyethylene or high-density polyethylene (HDPE). The molecule chains have fewer branches than is the case with LDPE and for that reason is sometimes called linear PE. Density: 58.3 to 59.8 lb/ft^3 (0.94 to 0.965 Mg/m^3). Crystallinity: 80% to 90%. Melting point: 239° to 284°F. (115° to 140°C.). HDPE (hard PE) is stiffer and has a harder surface than LDPE.

Types with a density of between 57.4 and 58.3 lb/ft^3 (0.925 and 0.940 Mg/m^3) are distinguished from other types of LDPE. These are known as medium-density polyethylenes (MDPE). This is also the little given to mixtures of LDPE and HDPE.

Characteristics: They are resistant to chemicals except for highly oxidizing acids and certain organic solvents. They are light, have a high degree of impact strength, a low amount of water absorption, and are inexpensive.

Uses: For a large variety of packing materials (foils, containers – even for foods), semifinished materials (tubing), household items.

POLYMERIZATE

Result of *polymerization. The meaning of this word is basically the same as *polymer.

POLYMERIZATION P. 22

Chemical reaction during the production of plastics. Similar molecular building blocks (monomers) combine with each other to create chainlike macromolecules.

POLYMERS

Also called polymeric materials, they are macromolecular substances whose molecules (chain molecules, molecular chains) are built up from a very large number of smaller building blocks (monomers). The structure is ei-

ther completely chain-shaped or is more or less composed of branch side-chains or groups. Compounds composed of only a few monomers (oligomers) are, in the strict sense, not polymers. In general, polymers are divided into *homopolymers and *copolymers. They are manufactured by *polymerization, *polycondensation and *polyaddition. The number of the mers in the chain determines the degree of polymerization.

POLYOLEFINS (PO)

A general term for all *polymers that are built up from *olefins. Some especially important polyolefins are *polybutylene-1, *polyethylene, *polypropylene (*cross-linked polyethylene).

POLYPROPYLENE (PP) P. 27

A thermoplastic material of the *polyolefin group that is similar to PE but harder. It is manufactured from propylene under low pressure (14.5 to 145 psi or 0.1 to 1 MPa) and at a low temperature (122° to 212°F. or 50° to 100°C.) in the presence of catalysts. It has a high crystallinity with a melting point of about 329°F. (165°C.). It has a low density of about 55.8 lb/ft^3 (0.9 Mg/m^3).

Characteristics: Has good mechanical properties, is somewhat brittle when cold, is resistant to fatigue, has good electrical qualities, is resistant to chemicals (similar to PE) and is insensitive to water. Further improvements can be achieved through copolymerization.

It has a wide variety of uses, especially when mechanical and thermal strength are required. These include semifinished products, motor-vehicle and washing-machine parts, containers, propellers, medical articles.

POLYSTYRENE (PS) P. 27

This is a thermoplastic material with an amorphous structure and a softening temperature of about 212°F. (100°C.). It is a glass-clear, polymeric material that can be colored in any tone. It is hard but breakable, is resistant to water but not to chemicals and has good electrical qualities. It is easily formed by using an injection molding system. Copolymerization improves its qualities. A special advantage: it is inexpensive.

Uses: for packing containers and for inexpensive, commonly used items, especially disposable goods. It is of great importance also for the production of foam products (for insulating buildings and for articles that must be able to float).

POLYVINYLCHLORIDE (PVC) P. 27

A thermoplastic material, it is a polymer of vinyl chloride ($CH_2 = CHCl$) that, in its pure form, is colorless. Its softening temperature is about 176°F. (80°C.) with a density of about 86.8 lb/ft^3 (4 Mg/m^3). It is produced in a variety of copolymerized forms. Special characteristics can be brought out through a large number of *additives.

General charactistics: It has outstanding resistance to chemicals and a low softening point. It breaks down at high temperatures while giving off hydrochloric acid. Since it can be fused and glued, it is easy to work with. Uses: Hard PVC (without a softener) is used for semifinished materials such as tubing, corrugated tubing, slabs and so on. Soft PVC is used for foil, coatings, packing materials, hoses, etc. It is also used for producing foams.

PONT-À-MOUSSON METHOD (PAM) P. 77

PP

Abbreviation for *polystyrene.

PRODUCTION MONITORING P. 51

PS

Abbreviation for *polystyrene

PVC

Abbreviation for *polyvinyl chloride.

R

RADICAL, FREE

A group of atoms (a molecule fragment) with one or several unpaired electrons, that is, free valences. They are extremely open to reaction and unstable. They play a decisive role in

chain formation during the course of polymerization.

REFINERY P. 22

RELAXATION

In general this refers to the measurable time that it takes to reestablish an equilibrium after a sudden change in the conditions that are at the basis of a substance's current system.

The relaxation of stress is of importance in determining the behavior of many plastics. It refers to the gradual subsiding of the inner stress that was built up by the rapid deformation of a plastic object. The return to a state of equilibrium is based upon plastic and viscoelastic behavior that is determined by the molecular structure of the material. Noncross-linked molecules (as, for example, in soft, amorphous plastics) move quite readily in relationship to each other. A substance of this kind displays a greater relaxation effect than a cross-linked, hardened material (thermosets, rubber). Breaking and restructuring of the molecular connections can also lead to the stabilization of a substance in its deformed state.

A weak relaxation effect is desirable in the case of elastomers and synthetic rubbers that still have to provide a "cushioning" effect even after long periods of forced deformation.

Relaxation increases along with a rise in temperature and under the influence of oxygen.

RUBBER P. 26

Natural rubber, synthetic rubber. Macromolecular materials that, by means of cross-linking (vulcanization), are processed into the rubber that is used for various products.

S

SAFETY COEFFICIENT P. 50

Also called the safety factor.

SATURATED POLYESTER

*Polyester, saturated.

SCRATCHES P. 58

SECANT MODULUS P. 45

SEMI-FINISHED MATERIAL

A product made of molding material that will receive its final shape during further production procedures such as remolding, cutting or joining. Examples are foils, bars, tubing, and rods.

SHELLAC P. 26

SILANE CROSS-LINKING P. 77

SILICON DERIVATE P. 77

SILOXANE BRIDGES P. 77

SIOPLAS METHOD P. 77

SOFTENERS

Also called plasticizers, these are substances that improve the plasticity and breaking behavior of polymeric materials. Two different types of softeners are used. Internal softeners are build into the molecular structure, usually through *copolymerization. External softeners are mixed into the plastic that is to be softened. There is a further division into primary and secondary softeners. Primary softeners serve only the purpose of softening. Secondary softeners are also used for adjusting other properties.

STABILIZERS P. 68

*Additives that serve to protect polymers during processing, manufacturing and actual use from breakdown and deterioration by heat, oxygen, light (aging preventative) and ultraviolet rays.

SURFACTANT

A surface active substance whose molecules consist of one hydrophilic and one hydrophobic part. The one part strives to dissolve in water and the other does not. Ionic surfactants are either anionic or cationic depending upon the charge of their most forceful part.

Synthetic surfactants that have a cleansing effect are known as detergents.

SYNTHETIC HORN P. 26

SYNTHETIC PLASTICS P. 25

Commonly called simply "plastics", they have not yet been defined in the DIN standards as a general group. In general, they are organic materials that come from natural products or from the separation of coal, crude oil or natural gas. They are characteristically made up of *polymers. They are plastic and so can be shaped by processing either once or repeatedly depending upon their type. In almost all cases, they are mixed with *additives. As a group they are divided into *thermosetting plastics, *elastomers and *thermoplastics.

SYNTHETIC RESINS

In the field of plastics technology, these are the raw materials that are used as the starting point for the actual plastic products. They are used in the manufacture of varnishes, glues and, in general, any product requiring a binder (industrial resins).

SYNTHETIC RUBBER

Polymers that can be processed into *elastomers similar to natural rubber by using the same methods as in rubber technology, that is, *vulcanization (wide-mesh cross-linking).

T

TACTICITY

Refers to the kind of spatial arrangement of the side groups in a molecule chain (steric order). The following groups are distinguished from each other in the case of plastics:

a) Atactical polymers: irregular (static) arrangement of the side branches.
b) Isotactical polymers: the branches are situated on the same side of the main chain.
c) Syndiotactical polymers: the branches are arranged in a regular pattern, changing off from side to side.

TANGENTIAL MODULUS P. 45

TEAR STRESS

Also known as break stress. *Tensile test.

TEAR STRETCHING

Also known as break stretching. *Tensile test.

TEMPERATURE CYCLE P. 64

TENSILE TEST

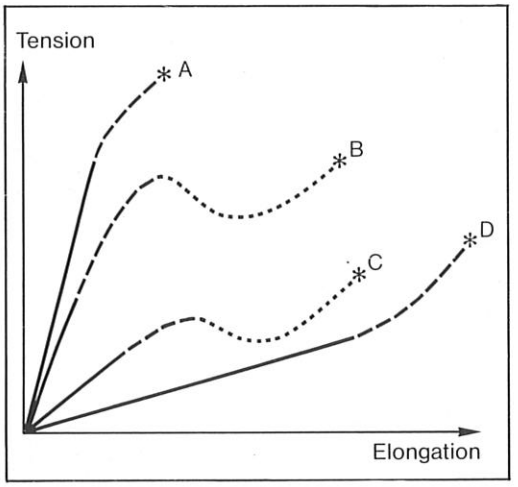
This is a materials test that is used to determine certain mechanical properties through the use of pressure at a given point. In the case of plastics, it is conducted according to ASTM D638. The results of the measurements are presented in a stress-elongation graph. In it, the stress σ (lbs/in^2) or σ (N/mm^2) is plotted out against the relative elongation ε in% (also known as strain).

The curve that results provides information concerning the following characteristics of the material that is being tested:

Yield stress σ_s: At this stress, the material leaves the elastic stage and enters the plastic stage. (The fully elastic stage is indicated by a solid line, the viscoelastic by a broken line.) The corresponding elongation is signified by ε_s.

The tensile strength σ_B is the tension at the time the greatest amount of force is applied. It is always situated at the highest point of the curve. ε_B is the elongation at the time the greatest amount of force is applied.

The asterisk (*) on the curve indicates the point at which the material broke. This pro-



vides a reading of the material's breaking strength (breaking stress) σ_R and its elongation at the point of breaking ε_R.

The rise in the somewhat linear part of the curve (the elastic stage) corresponds to the *elasticity modulus: $\tan \alpha = \sigma/\varepsilon = E$.

The diagram shows the stress-elongation lines for four different materials. A is a hard and brittle material such as a reinforced thermosetting plastic. B is a hard and ductile material such as acetal resin. C is a soft and ductile material such as LDPE. D is a soft and extremely ductile material such as soft rubber.

THERMAL CONDUCTIVITY (λ)

A property of materials that indicates the amount of heat (Btu) that penetrates a body with a specific cross section and thickness in a certain period of time (hr). It is expressed as Btu/(hr · ft · °F). In a static system, the following relationship would be in effect:

$Q = \lambda \cdot A \cdot \Delta T \cdot 12/\delta$ (Btu/hr)

If the thermal conductivity is related to specific wall thickness, the result would be the termal conductance coefficient:
Λ [$\lambda \cdot 12/d$ in Btu/(hr · ft² · °F)].

THERMAL EXPANSION (a)

Also called heat expansion, it refers to the characteristic of a body to expand in the presence of heat. The change in length as a function of the change in temperature is shown in this equation: $\Delta l = l \cdot a \cdot \Delta T$. a here is the linear thermal-expansion coefficient in ft/ft · R.

THERMAL-PENETRATION COEFFICIENT (k)

This coefficient or its reciprocal, thermal-penetration resistance (l/k)(sometimes called R-total thermal Resistance), combines the thermal-conductance coefficient (Λ) and the thermal-transfer coefficient (α) according to the equation:

$l/k = l/\alpha_1 + \delta/(12 \cdot \lambda) + l/\alpha_2$ (ft² · hr · °F/Btu)
$\{k = l/(l/k)\ [= U]$ (Btu/(hr · ft² · °F)}

THERMAL-TRANSFER COEFFICIENT (α)

This factor, expressed in Btu/(hr · ft² · °F), describes the transfer of heat from a bordering surface as, for example, from the outside surface of a building to the air. It is a function not only of the change in temperature but also of the air movement on the surface.

α is of great importance when designing equipment to be used for various processes in the field of plastics technology.

TENSION-CRACK CREATION P. 56

THERMOELASTICS

This is the term used for plastics that are moldable at high temperatures but do not begin to flow before reaching the temperature at which they deteriorate.

THERMOPLASTICS P. 26

They are also called plastomers. This is the general term used to refer to all *polymers whose molecule chains are not linked with each other through chemical bonding (cross-linking) and whose characteristic quality consists of the fact that they can be repeatedly heated to flowing. They are still stable under their glass temperature (freezing temperature) or crystal melting point. These temperatures must lie significantly above their proposed operating temperature.

The most important thermoplastics are polyolefins (PB, PE, PP), *polystyrol (PS), *polyvinyl chloride (PVC).

THERMOSETTING PLASTICS P. 26

Also known as thermosets, this group includes all curable synthetic resins or molding materials and the hardened materials that are produced from them. They are irreversibly formed and tightly cross-linked. The characteristic features are a high degree of strength and hardness, no softening or melting even at high temperatures, insolubility by organic solvents and loss of their plasticity after they have hardened.

The most well-known thermosetting plastics are the *aminoplastics, the *phenoplastics, the epoxy resins (EP) and the *UP resins.

THERMOSTABILITY P. 61

TIME-TO-FAILURE STRENGTH (CREEP STRENGTH) P. 52

TOLERANCES P. 72

U

UF

Abbreviation for urea formaldelhyde resin. *Aminoplastics.

UHF CROSS-LINKING P. 78

ULTRAVIOLET LIGHT RESISTANCE

A form of resistance possessed by some plastics to energy-rich waves. Ultraviolet rays have a catalytic effect and so they make the situation more favorable for oxygen-caused deterioration. Since the amount of the damage is dependent upon the degree of the rays' penetration, thin and uncolored materials are especially sensitive to ultraviolet rays. An improvement in the resistance of a plastic to ultraviolet rays can be made through *additives such as *ultraviolet-ray stabilizers, *antioxidants and pigments.

ULTRAVIOLET STABILIZERS

Also called ultraviolet absorbers, they are chemicals that are added in small amounts to plastics for the purpose of inhibiting the destructive effect of the energy-rich ultraviolet rays present in sunlight and the deterioration caused by oxygen or heat.

UNSATURATED STATE

The occurrence of double and triple carbon unions in an organic compound. It is the prerequisite for the ability of monomers to be polymerized.

UP

Abbreviation for unsaturated polyesters. *Polyester, unsaturated.

V

VMPA

Association of Materials-testing Boards (Verband der Materialpruefungsaemter).

VPE

DIN-accepted abbreviation for cross-linked *polyethylene (*XLPE, *PEX, XPE).

VULCANIZATION P. 26

A cross-linking process in which rubber is transformed from a moldable and plastic state to a elastic and hard state. One of the earliest agents used for vulcanization was sulphur.

X

XLPE, XPE, (*PEX, *VPE)

Abbreviations used for cross-linked polyethylene in literature written in English.

Y

YOUNG'S MODULUS

*Elasticity modulus.

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