Glossary

A

Active anhydrite. A physical form of calcium sulfate, CaSO₄, that dissolves readily in water.

Addition. Material other than gypsum or water, which is interground with clinker.

Alite decomposition. Alite is a solid solution based on Ca₅SiO₅ and comprises the major mineral phase of portland cement. At or below ~1275°C it is thermodynamically unstable and may decompose to mixtures of Ca₂SiO₄ (belite) and lime (CaO) if slowly cooled.

Alkali. A substance having marked basic properties—generally sodium or potassium oxides or hydroxides.

Alkali sulfates. Potassium or sodium sulfate, K₂SO₄ or Na₂SO₄, and their mutual solid solutions.

Andalusite. Aluminum silicate.

Anhydrite. Anhydrous calcium sulfate β-CaSO₄. It may occur as such in nature, or it can be produced by heating gypsum to about 400°C. (Heating to lower temperatures produces so-called “soluble” anhydrite, or γ-CaSO₄).

Anthracite. A hard, natural coal which contains approximately 85-95 percent carbon and a low percentage of volatile matter.

Argillaceous. Composed primarily of clay or shale.

Ash. The inorganic residue remaining after combustion of a fuel.

Aspect directory. The component in the modern IIT platform that keeps track and stores the association between aspects (see aspect object). Once installed, changes to an aspect object are communicated via the aspect directory to all relevant parts of the system automatically.

Aspect Integrator. A platform designed to provide quick access to information needed to operate a device (see Aspect object) from one interface in a “plug and produce” installation.

Aspect object. The combination of characteristics (or aspects) forming a software shell bundling an equipment component with a library of associated drawings, manuals, etc., in a consistent electronic format. An aspect object can be a finished product, an order, or raw material or stock.

ASTM. American Society for Testing and Materials.

At-risk. Subject to potential injury, illness, loss or damage.

Automatic external defibrillator (AED). An electrical device that re-establishes proper heartbeat of a person who has suffered cardiac arrest.

Automation. Refers generally, to the automatic operation of subsystems, measurement devices (sensors/analyzers), controllers, and their integration.

B

Bacteria. Single-celled or noncellular microscopic plants with pathogenic potential, and which collect in colonies.
**Barrel.** Unit of measure for portland cement corresponding to 4 sacks of 94 lb. each.

**Baud.** A measure of data transmission speed. 1 baud is equal to 1 electronic state change per second. Being replaced by bps or bits per second.

**Bauxite.** Raw material composed primarily of $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$ (gibbsite) together with $\text{SiO}_2$ and $\text{Fe}_2\text{O}_3$.

**Bioaerosols.** Airborne liquid or solid particles released from a living organism, small enough to remain dispersed in air for a prolonged period of time.

**Bleed air.** Air which is introduced into or taken from the kiln gas stream, at a point subsequent to introducing combustion air.

**Bloodborne pathogen (BBP).** An organism capable of producing disease and which is carried in the bloodstream.

**Bogue formulae.** Formulae used to calculate potential phase constituents of clinker.

**Brick retainer.** Metal or ceramic segments radially attached to the kiln shell to keep the lining from moving toward the discharge end.

**Bubble, blister.** Permanent deformation caused by a red spot on the kiln shell.

**Buildup.** Salt and kiln dust deposits attached to the refractory lining.

**Bullnose.** Refractory lining connecting a wall to a ceiling in the cooler and preheater.

**Burnability.** The burnability is the term used for how easily the raw mix combines to form the clinker minerals, primarily alite.

**Burnability index (BI).** A number defining the lime-combining ability of the kiln feed. Higher BI means hard to burn clinker.

**Burnability factor (BF).** Used as a gridline to show if a clinker is easier or harder to burn. Higher BF means hard to burn clinker.

**Burning.** Sintering or near-fusion in a kiln, resulting in chemical combination of the raw materials and formation of clinker.

**Burning zone.** Kiln zone with a stable, permanent coating; the location in the kiln where alite is formed.

**Bypass.** A device for gas separation at the kiln inlet, that allows to condense and remove undesired gas components from clinker burning.

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**C**

**Calcareous.** Composed primarily of calcium compounds.

**Calcination.** Removal of $\text{CO}_2$ from carbonates in raw mix.

**Calcining zone.** Kiln zone where carbonates and hydroxides in the raw mix are thermally decomposed to oxides.

**Calcium langbeinite.** A mineral close to $\text{Ca}_2\text{K}_2\text{(SO}_4)_3$ in composition.

**Cam lining.** Lining with bricks of different heights to create cams.

**Carcinogen.** A substance capable of causing cancerous tumors to form or tissues to grow abnormally.
**Cardiopulmonary resuscitation (CPR).** A system of re-establishing the circulatory and respiratory system functions of a person who has suffered cardiac arrest, by manually and externally compressing the heart and breathing into the person's lungs.

**Castable.** Refractory concrete installed behind forms.

**Cement production laboratory.** This is differentiated from a research laboratory in that a production lab is specifically established to provide analytical data results for production quality control and quality assurance. Output from this type of laboratory dictates consistency in production, maintenance, reconciliation of information, production accounting, and process workflow.

**Cement rock.** Natural, impure limestone, which contains the ingredients for cement in approximately the required proportions.

**CEMS.** Continuous emission monitoring system.

**Chalk.** Soft limestone composed chiefly of the shells of small marine life.

**Chemical potential.** For a substance in a mixture, the change in Gibbs free energy caused by the addition of an infinitesimal number of moles of the substance is defined as its chemical potential.

**Chemically-induced defects.** Atom vacancies or interstitials introduced mainly to valence – compensate for ionic substituents of unlike charge, e.g., of Al$^{3+}$ for Si$^{4+}$, in a crystal structure.

**Chock.** A device, which when placed on the ground at the downhill side of a wheel on a piece of mobile equipment, prevents the equipment from rolling unexpectedly downhill.

**Clay.** An earthy plastic material high in silica, alumina, and sometimes iron.

**Clinker.** The partially fused product of a kiln which is ground to make cement.

**Clinker cooler.** Equipment used to cool clinker by motion or air.

**Clinker kiln dust.** Fine particles swept out of the kiln with the cooler excess air and normally trapped by electrostatic precipitators or baghouses.

**Clinker melt.** Portion of the raw mix that melts in the burning zone. Usually about 25% by mass at 1450°C.

**Clinker rings.** A buildup in or near the back of the burning zone of a kiln, in which melted or fused raw materials have adhered to the kiln lining in excessive amounts.

**Coatability.** Ability of the raw mix, clinker, or brick to develop coating.

**Combustible.** The capacity of a substance to catch fire or support combustion.

**Combustible liquid.** A liquid that will burn and has a flashpoint at or above 38°C (100°F).

**Compressed gas.** A gas contained at a pressure greater than 276 kilopascals (40 PSI) at 21°C (70°F).

**Condensation zones.** In a cement kiln, a portion of the kiln in which cooling leads to conversion of some components of the gas stream to liquid or solid phases.

**Conductivity.** The constant of proportionality between electrical current and electrical potential.

**Confined space.** A space for which there is limited means of egress, persons can get inside to perform work and is not intended for normal occupancy.

**Connectivity.** The means by which all components and subsystems interface.

**Convection.** Heat transfer in a gas or liquid by the circulation of currents from one region to another.
**Corrosive.** A substance that causes irreversible damage to living tissue at the point of contact. Corrosive pH factors lie between 0-2 or 12-14.

**Cross belt analyzers.** Field located analyzer that measures the chemical composition of the material on a belt conveyor passing through the analyzer.

**Crystal-melt interface.** The physical contact, or interface, between a solid and molten phase.

**Curb.** Bottom of the sidewalls in the clinker cooler.

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**D**

**Dam.** Refractory construction that opposes material flow through the kiln.

**Data warehouse.** A term used to define the location of accumulation of data storage in a preferred common database for use by all consumers of needed information to run a cement plant in a smooth manner.

**DCS.** Distributed Control System. An industrialized computer system used to control process equipment. Originated with analog control applications.

**Dendritic growth.** An exaggerated complex crystal morphology, often with fractal dimensionality, typical of crystal growth with undercooling: from the Greek, “tree-like”, referring to its typical shape.

**Dermatoses.** Abnormal conditions of the skin.

**Dew point.** Temperature which, at fixed pressure, a vapor condenses to liquid or solid.

**Diffusion.** Diffusion is the process by which matter is transported from one part of a system to another as a result of random molecular motion.

**Discharge zone.** Kiln zone between the lower transition zone and the nose ring.

**Discrete controllers.** A control system used in simple circuits with central operator stations having command capability. Not commonly used when low maintenance and cost of sustainability are important.

**Discrete interfaces.** Refers to the uniqueness of interfaces for systems or devices that may present difficulties in linking with other devices or systems unless successfully integrated via a common database.

**Dog leg.** Popular name for permanent kiln misalignment. Crankshaft effect.

**Dolomite.** Double carbonate of calcium and magnesium.

**Dwell time.** Length of time spent under a particular set of thermal conditions.

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**E**

**Effective safety practices.** Once a good organizational safety structure is in place, the next requirement is for a broad-based, comprehensive understanding of hazards and injury potential. Analysis of site-specific hazards, formulation of good safety policies and application of proven safe work procedures follow. “Best practices” are generally recognized industrial work standards that minimize or negate hazards and permit tasks to be completed with minimal risk of injury, illness or property damage. Best practices may be codified as regulations, exist as equipment manufacturers’ operating procedures or be published as corporate standards. Cement facilities should develop work procedures that apply the principles of best safety practices in the context of local plant conditions. Activities to which best practices should be applied include: burning and welding operations, confined space entry, contractor utilization, crane and aerial lift operation, emergency planning, excavation and trenching, fire and explosion prevention, hand and power tool use, hazardous
energy control, incident investigation, ladder and scaffold use, mobile equipment operation, quarrying, railroad operation, stockpiling materials and more.

**EIS.** Enterprise Information System. See ERP.

**Elastic modulus.** Ratio between stress and strain.

**Elastic strain energy.** Energy accumulated in a crystal as a result of stress, either applied or self-generated, perhaps as a result of polymorphic transition.

**Electronegativity.** Elements which easily forms negative ion are electronegative; the qualitative measure for how easily negative ions are formed.

**Electrostatic precipitator.** Collector for fine dust, particularly in kiln gases. Dust laden air is passed through a large chamber where dust particles are ionized by contact with chains or rods connected to one pole of a high voltage rectifier, and then attracted to and collected on the sides of tubes or collector plates connected to the other pole. Collector are rapped periodically to discharge dust.

**Ellestadite apatites.** Refers to a particular structure, that of apatite, nominally a phosphate, but in ellesstadite chemically substituted giving, for example, Ca$_5$[(Si, P, S)O$_4$]$_3$(F, OH, Cl).

**Emissivity.** The ratio of the radiation emitted by surface to the radiation emitted by a black body at the same temperature.

**Endothermic.** Chemical reaction requiring the continued absorption of heat such as the calcination or decomposition of limestone.

**Energy balance, heat balance.** Equality of the net energy flow into and out of a certain reaction space through physical flows and reactions.

**Enthalpy.** A thermodynamic function of a system, equivalent to the sum of the internal energy of the system plus the product of its volume multiplied by the pressure exerted on it by its surroundings.

**Ergonomics.** A multidisciplinary activity dealing with: interactions between people and their work environments, and efforts to eliminate or minimize job task risk factors that can cause physical disorders.

**ERP.** Enterprise Resource Planning. A business system intended to link all activities within a business enterprise for purposes of connecting the various departments and functions in a manner which benefits the specific objectives and purposes of supplier/customer links to serve the business in a profitable and traceable manner.

**Equivalent alkali:** The weighted sum of the sodium and potassium contents in a hydraulic cement, expressed as percent sodium equivalents: $\%Na_2O_{eq} = 0.658 \times \%K_2O + \%Na_2O$.

**Eutectic point.** The lowest temperature of formation of melt in a mixture is called the eutectic point (Greek: easily melted).

**Evaporation enthalpy, condensation enthalpy.** Enthalpy that is related to the evaporation of a liquid into a vapor or vice versa.

**Exothermic.** Chemical reaction in which heat is given off after the action commences; i.e., cement hydration, some reactions of clinkering in the burning zone.

**Experience modification rate (EMR).** An insurance term related to an organization’s positive or negative performance in regard to claims and losses.

**Exsolution.** A process whereby a homogeneous single phase spontaneously nucleates a second phase or phases, thus resulting in inhomogeneities: the process frequently occurs without change in bulk composition.
**Extended defects.** Crystalline defects extending over a number of atoms, often propagating along an axis or plane with definite crystallographic orientation.

**False set.** A manifestation of an abnormal early hydration reaction in which rigidity or partial setting of the paste occurs in a few minutes. When stiffened paste is remixed without further addition of water it recovers plasticity.

**Feed shelf.** Slope through which the feed enters the rotary kiln.

**Feldspar.** Any group of framework crystalline minerals composed primarily of aluminum silicates.

**Fieldbus.** Communications link used between different levels of process controllers. Also, Profibus.

**Field sensors.** Refers to analyzers or sensors which are located in the process or otherwise remote from a central laboratory or related processing unit.

**Finish grinding.** The grinding of clinker into finished cement usually with the addition of about 3% to 5% gypsum.

**Fireclay brick.** Brick made strictly with pressed or extruded refractory clay.

**Firewall.** A device that protects a network from unauthorized access.

**Firing systems, primary and secondary.** The primary firing system is the main burner of the kiln and its supporting devices. Secondary firing systems are additional burners, which may be applied e.g., at kiln hood, kiln inlet or in the calciner.

**Flammable.** The capacity of a substance to be easily set on fire or support combustion.

**Flammable liquid.** A liquid having a flashpoint below 38°C (100°F).

**Flashback arrestor.** A device on an oxy-fuel burning torch that prevents a flame from burning back into the torch’s tip or hoses.

**Flashpoint.** The temperature at which a liquid gives off a sufficient amount of vapors to support combustion.

**Floating anchor.** Ceramic or metal anchor that can move freely with the castable.

**Flux.** A substance which, when added in small amounts, lowers melting points and enhances mass transport without otherwise affecting phase relations.

**Fluxing.** Lowering of the brick melting temperature by infiltrates.

**Fly ash.** Residue of fused spherically shaped particles from the burning of powdered coal.

**Foot-candle (fc).** A unit of illumination equal to one candela, one foot from the light source.

**Free lime.** CaO in clinker and cement which has not combined with SiO₂, Al₂O₃, or Fe₂O₃ during the burning process, usually because of underburning, insufficient grinding, or the presence of trace inhibitors.

**Fume.** A fine, solid particle, often metal or metal oxide, formed by rapidly condensing gases.

**Fungi.** Microscopic plants that live or feed on dead or decaying organic matter.

**Gaseous emissions.** Reactions of or amongst solids leading to formation of a gas, as for example liberation of CO₂ from calcium carbonate, such that the gas is discharged as an effluent or emission.
**Gibbs free energy.** A measure of the driving force for a chemical reaction, typically measured in units of kJ/mole of substance.

**Glassy iron blast furnace slag.** A silicate composition formed in the blast furnace process of iron-making, initially molten and rapidly quenched into a largely glassy phase.

**Gravimetric analysis.** Quantitative analysis based on weight of samples, residues, precipitates etc.

**Gunning mix.** Refractory concrete installed by projection with an air gun.

**Gypsum.** Hydrated calcium sulfate added to portland cement clinker and interground to control the setting time.

**Hardgrove grindability index.** A measure of how difficult material (usually fuel) is to grind (higher is easier).

**Hazard.** The injurious properties of a substance or the probability of injury or damage.

**Health and industrial hygiene.** Industrial hygiene is the science of anticipating, recognizing, evaluating and controlling workplace environmental factors and stressors that can lead to illness or impaired health of workers or those in the surrounding community. Industrial hygiene practice requires detailed knowledge of a broad array of physical and life sciences, and an organized and analytical approach to problem solving. The cement industry has its own set of unique industrial hygiene hazards that should be recognized, evaluated and controlled before they become harmful. These hazards can be divided into four main categories: 1) chemical hazards that can be irritating or toxic to the body’s organs or systems, 2) physical hazards, such as noise, vibration, radiation, and thermal or pressure extremes, 3) ergonomic stresses resulting from an improper interface of workers and workplace machines, tools and procedures that repetitively stress vulnerable areas of the body, and 4) biological hazards from living organisms that can adversely affect bodily functions.

**Heat of crystallization.** Latent heat released by a melt in the course of cooling as it converts to a solid crystalline phase or phases.

**Heat of conduction.** The transmission of heat through a conducting medium without perceptible motion of the medium itself.

**Hematopoietic toxin.** A substance that can damage the blood or the body’s ability to form blood.

**Hemihydrate.** Shorthand for CaSO₄ · 0.5H₂O.

**Hepatoxin.** A substance that can cause damage to the liver.

**Hexavalent chromium.** Chromium ion with oxidation state +6, very soluble and toxic.

**Histoplasmosis.** An avian borne illness of the respiratory system caused by inhaling certain fungal spores.

**HLC.** High Level Control. A closed-loop expert control system (“best” target process).

**Hot zone chemistry.** Collective term applied to reactions occurring in the hottest part of the kiln, typically > 1000°C and up to 1500°C material temperature.

**Hub.** Device used to connect computers to a network.

**Hydration:** The chemical reaction of hydraulic cements with water. See Table 9.1.7 for a summary.

**Hydraulic cement.** Cement capable of setting and hardening under water.

**Hypothermia.** Subnormal temperature of the body’s core, often associated with impaired physical and/or cognitive abilities, sometimes resulting in injury, illness or death.
I.D. fan. Induced draft fan.

I.S.O. International Standards Organization.

Ignition loss. The percentage loss in weight when the as received sample is ignited to constant weight at 900-1000°C.

IIT. IndustrialIT is a trademarked product of ABB. Refers to a type of information architecture that links multiple applications and systems with historical and real-time data.

Immediately dangerous to life and health (IDLH). The maximum concentration of a substance from which one could escape within 30 minutes without incurring escape-impairing symptoms or irreversible health effects.

Immiscible liquids. Two or more liquids which are incompletely soluble, e.g., oil and water.

Incidence rate. A measure of frequency of injury or illness per person-hour worked, usually workdays lost, restricted or requiring certain medical treatment, usually compared to a standard of either 200,000 or 1,000,000 person-hours.

Incident. An unplanned or unexpected event, usually with the potential for causing injury, illness or property damage.

Industrial hygiene. The science of anticipating, recognizing, evaluating and controlling workplace environmental factors and stressors that can lead to illness or impaired health of workers.

Industrial information technology. See IIT. A technique that bridges the gap between industrial and business assets, and the IT required to integrate these several systems in real time.

Infrared. Radiation beyond the visible light spectrum with wavelengths longer than red light.

Insoluble residue. The material remaining after a cement is treated successively with hydrochloric acid and sodium hydroxide of specific concentrations and for designated time.

Insufflation. Blowing material such as CKD into the burning zone of the kiln either through the fuel pipe or a separate pipe.

Interfaces. The means by which data collectors, instruments, or subsystems connect.

Iron alumina ratio. $\text{Fe}_2\text{O}_3/\text{Al}_2\text{O}_3$; it varies from plant to plant depending on raw material and type of cement being produced. At some plants the reciprocal is used.

Irritant. A substance that causes a reversible inflammatory effect to living tissue at the point of contact.

IS. Information System. A generic term used to designate any system or group of systems incorporating Information Technology (see IT and IIT).

IT. A general term referring to industrial technology, or a department within a company dedicated to information management.

Iteration. A computational procedure in which the desired result is approached through a repeated cycle of operations, each of which more closely approximates the desired result.

Jaw crusher. Crusher consisting of two plates farther apart at the top than at the bottom. One is movable and one stationary. The movable plate which is attached at the upper end is given a reciprocating motion by means of an eccentrically operated arm. Feed is crushed as it passes between the two plates.
**Glossary**

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**K**

**Kaolin.** White colored clay, principally an aluminum silicate of low iron content used as a raw ingredient in cement manufacture.

**Klin.** Equipment in which a raw mix is dried, calcined, and burned into clinker at a temperature of about 1450°C.

**Kiln rings.** Annular deposits forming symmetrically on the inside of a rotary cement kiln at particular points along its length such that they restrict the flow of solids.

**Kiln shell scanner.** Field located analyzer that measures the temperature of a kiln shell.

**Knudsen effusion method.** An experimental technique for determining vapor pressures from the isothermal mass flow through a small orifice.

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**L**

**Laboratory automation.** Automated management and handling of samples, sample preparation, and analyses, or a combination of these activities.

**LAN.** Local Area Network. A network of computers located on one site.

**Lazy flame.** Kiln flame characterized by slow undulating movements approximately following the velocity of the flow of surrounding air.

**LCC.** Life Cycle Cost(s). Refers to the cost of an automation system for a defined period; varies from company to company, but normally is calculated for ten years. A complete evaluation should include costs of maintenance, modification and sustainability.

**Levels of automation.** Level and degree of manual, semi-automatic, and full automation of a process or a laboratory.

**Lime.** CaO, Calcium oxide.

**Lime kiln.** A stationary or rotary kiln to calcine limestone and produce quicklime or calcium oxide.

**Lime ratio.** CaO/(SiO2+Fe2O3) ratio of lime to silica plus alumina and iron oxide. Used as a check of the chemical composition of the raw mix.

**Lime saturation factor.** An approximate equation used to predict the maximum chemical CaO which can be combined into clinker phases, e.g., alite, belite, aluminate and ferroaluminate without free lime appearing in clinker: see Appendix, for its calculation.

**LIMS.** Laboratory Information Management System(s). Refers to a system or subsystem designed to administrate, manage, report, assign, and integrate functionally and technically for the cement production laboratory. May be discrete or modular.

**Load.** Material being ground in a mill or burned in a kiln.

**Logic control, logic system.** The type of control/system that defines the uniqueness and characteristics of the cement plant process flow.

**Low alkali cement.** Cement containing less than 0.6 percent (Na₂O + 0.658 K₂O).

**Low heat cement.** Cement (type IV) characterized by low percentages of tricalcium silicate and tricalcium aluminate.

**Lower transition zone.** Part of the kiln between the discharge zone and the burning zone.
Magnesia. Magnesium oxide, MgO.

Magnesite. Magnesium carbonate, MgCO₃.

Maintenance support. May be a module within a plant management system that automatically provides information as to scheduled or event-driven programming and historical maintenance activities. In the most systems, this model is activated by sensor input on an automatic basis, providing dynamic information as opposed to passive, historical recording.

Material safety data sheet (MSDS). An organized, written form that communicates information about a substance in regard to its manufacture, chemical and physical properties, hazards and safe use procedures.

Melt. The 20-30 percent of the mass of raw material which has become molten during clinkering (liquid phase) Consists primarily of aluminum and iron compounds.

MES. Manufacturing Execution System. Those production units within a cement plant that are concerned with the equipment functionality and performance. Linking to ERP systems in the modern plant enhances MES.

Metastable crystallization. Formation of a crystalline phase or phases which, under conditions of the crystallization, are either not the stable phase or phases or whose compositions exceed the thermodynamically-stable limits of solid solution.

Metric. A type of measurement or a measurement system.

Mill scale. High iron waste material obtained from rolling mills in steel plants and often used as a component of the raw mix when Type II or Type V is manufactured.

Mineralized cements. Cement made with a mineralizer, i.e., a substance which promotes reaction by altering the thermodynamic stability of one or more constituent phases. See also flux and mineralizers.

Mineralizer. A material that accelerates the reaction rate and promotes the formation of C₃S.

Minor elements. Broadly, any chemical element calculated in oxide form and present in amounts less than 1 atomic percent in clinker.

Misalignment. Kiln deviation from its longitudinal axis.

Mist. Liquid particles suspended in air, formed by splashing, foaming or atomization.

Modem. Device used to convert digital signals from computer equipment to analog signals for transmission on copper telephone line. Also converts the analog signal back to a digital signal. (modulate, demodulate).

Modulus. One of several ratios used in calculating the chemical composition of the raw mix i.e., lime ratio, silica ratio, molecular ratio.

Molecular dynamics. A scheme for calculation of the stability of a molecular or ionic combination from first principles.

MTDATA. Thermodynamic routine for calculation of thermodynamic quantities and expressing results, for example as a phase diagram; acronym for metallurgical thermodynamic database.

Mud ring. Solid slurry rings in the chain section of wet kilns.

Mullite. Mineral of composition 3Al₂O₃ · 2SiO₂.

Mutagen (also called teratogen). A substance that can alter a cell’s genetic information and lead to undesirable inherited conditions.
**N**

**Natural cement.** The product obtained by finely pulverizing calcined argillaceous limestone. The temperature is no higher than necessary to drive off CO$_2$.

**Nephrotoxin.** A substance that can cause damage to the kidneys.

**Neurotoxin.** A substance that can cause damage to or adversely affect the brain, central nervous system or nerve cells.

**Nose ring.** Discharge of the kiln emptying into the cooler.

**Nucleation and growth.** Mechanism whereby atoms or ions coalesce to form nuclei, some of which subsequently accrete to become discrete crystals.

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**O**

**OCS.** Open Control Systems. A control system based on network methods that incorporates discrete instrumentation. Used to link components in a stepwise extension.

**Optimization.** In the present context, this refers to enhancement and maximum benefit for a process, activity, procedure, system or installed component. Minimizes costs while optimizing operations and benefits, as a major goal.

**Ovality.** Deviation of the kiln shell cross section from a true circle.

**Overburden.** Layer of soil or unusable rock or other earth formation on top of raw materials in quarries.

**Overburned.** Cement clinker is considered overburned if it has been exposed to too high a temperature, or for too long a residence time in the hot zone. This results in formation of too much liquid phase during the clinkering process and too dense and hard grinding clinker.

**Overlimed.** A raw mix is overlimed if it contains more CaO than required to combine with silica alumina and iron. This usually results in the presence of free lime in the clinker.

**Oxidizing flame.** Kiln flame to which more primary and secondary air is supplied than required for complete combustion. At the high temperature in the burning zone the excess oxygen maintains the iron in clinker as the ferric iron resulting in a darker and greenish cement.

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**P**

**Pack set index.** A measure of the dry flowability of cement powder (higher is stickier).

**Packed bed, particulate bed.** A pile of particles with a certain size distribution.

**Pads.** Sacrifice steel segments between the tires and the kiln shell.

**Particle size analyzer.** Field located analyzer that measures the particle size distribution of a powdered material such as cement.

**PC.** Personal computer.

**Periclase.** Magnesium oxide, MgO, having the NaCl structure type.

**PGNAA.** Prompt gamma neutron activation analysis.

**PID.** Proportional, integral, and derivative control.

**Pinch spalling.** Brittle fracture of the brick induced by radial pressure.

**Plastic.** Pliable refractory material applied by ramming.

**PLC.** Programmable Logic Controller. An industrial computer which is used to control process equipment. Originated in discrete control applications.
**Point defects.** Crystalline defects caused by omission of a constituent atom or ion from a lattice site or by inclusion of an extra atom or ion interstitially.

**Pozzolan.** A siliceous or siliceous and aluminous material, which in itself possesses little or no cementitious value, but will, in finely divided form and in presence of moisture, react with calcium hydroxide to form compounds possessing cementitious properties.

**Pre-cooling zone of a rotary kiln.** Part of the kiln between the burning system and the cooler, where the material starts to cool down.

**Preheater.** Heat exchanger before the kiln where the raw mix is heated and calcined in suspension.

**Presbycusis.** Hearing loss caused by aging.

**Primary air.** Combustion air introduced through the burner pipe.

**Process automation.** Refers to the automation of a discrete or integrated process unit within the cement manufacturing operation. Logs are created to define operability and uptime of the process flow.

**Production accounting.** Automated means for balancing production figures by integration of collected figures and reconciling them with reality. Provides coherency between these numbers and the different systems producing them in a heterogeneous environment (point historians, ERP, dispatch systems, sales administration systems, etc.).

**Profibus.** See Fieldbus.

**Pyrometer.** Measures the burning zone in a cement kiln using a device with a constant temperature for absolute signals. Spyrometer™ is a scanning pyrometer and is a trademarked product from the Quadtek Company.

**Pyroprocess system.** Includes the kiln, cooler, and fuels combustion equipment.

**Pyroprocessing.** Processing at high temperature.

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**Q**

**Quantitative X-ray analysis.** Determination, by X-ray powder diffraction methods, of the amounts of crystalline phases present.

**Quarry.** Place where rock-type raw materials are excavated in the open, and used for cement manufacture.

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**R**

**Radiation.** Energy radiated or transmitted in the form of rays, waves, or particles.

**Raw materials.** Naturally occurring rocks or materials, or waste products, suitable for the manufacture of cement.

**Raw mix.** Slurry or raw meal ground to desired fineness and correctly proportioned for burning in a kiln.

**Reactivity of alite.** Rate at which alite, ideally Ca$_3$SiO$_5$, reacts with water, comparison often being restricted to equivalent surface areas.

**Reducing areas.** Areas with low partial pressure of oxygen.

**Reducing flame.** Kiln flame to which insufficient combustion air is supplied. At the high temperature of the kiln, this condition may tend, among other effects, to convert iron in the clinker to ferrous compounds giving the cement a tannish color.
Glossary

**Refractory.** Kiln lining which can withstand high temperature without fusing and protect the steel kiln shell.

**Rietveld analysis.** A quantitative x-ray diffraction phase analysis of crystalline mixtures, such as clinker.

**Remote access.** Access to a system or piece of equipment from a location other than where the equipment is physically located.

**Remote control.** Control of equipment from a site other than where the equipment is physically located.

**Reproductive toxin.** A substance that can affect male or female reproductive systems and impair the ability to produce children.

**Respirator protection factor (RPF).** A numerical rating that measures multiples of permissible exposure to air contaminants afforded by respirator use.

**Ring.** Anular deposits of unwanted material on the refractory lining.

**Riser.** Vertical duct connecting the kiln to the preheater; vertical duct between preheater stages.

**Risk.** The probability of harm or damage.

**Robotics.** In the cement plant, certain automated laboratories (centralized) have a robot located strategically among an array of sample handling, preparation, cleaning, and analytical devices. Robots are used to simulate the precise, repeatable, and consistent transport of samples and sampling components, containers, and other devices between stations in the cement laboratory. Robotics are employed to reproduce the actions of a group (several human operators) of “best” technicians consistently according to a predefined work schedule.

**Router.** Similar to a switch but with some ability to provide security from unwanted data transmission on a network.

**Safety.** The freedom from risk or occurrence of injury, illness or property damage.

**Safety can.** A closed container of maximum capacity of 5 gallons, equipped with a spring-closing lid and flash arresting screen, and able to relieve internal pressure when heated.

**Safety management and organization.** An effective safety organization requires the combined talents, energies and involvement of executive and line managers, hourly leaders, production, maintenance and support staff personnel, medical providers and occupational safety and health professionals, all linked together in a common effort. Cement manufacturing companies and facilities should apply to safety management the same key business principles that guide any successfully managed process or organization. These key issues are: strategic and long range planning; leadership; effective management systems; responsibility and accountability; ownership, empowerment and motivation; good communication systems; information and measurement systems; and a good training and education process.

**Scawtite.** $\text{Ca}_7\text{(Si}_3\text{O}_9)_2\text{(CO}_3)_2\cdot 2\text{H}_2\text{O}.$

**Schiel cooling.** A special condition imposed on cooling such that crystalline phases continuously formed in the process are prevented from further reaction with melt.

**Secondary air.** Hot air returning from the cooler to the kiln.

**Sensitizer.** A substance, which on first exposure causes little or no damage, but which on subsequent or repeated exposures, can cause a marked response, not limited to the point of contact.

**Sensorineural hearing loss.** Hearing loss caused by damage to hearing cells in the inner ear.
**Setting time.** Time required for cement paste, mortar, or concrete to achieve a certain degree of rigidity.

**Severity rate.** A measure of severity of injury or illness per person-hour worked, usually workdays lost or restricted, usually compared to a standard of either of 200,000 or 1,000,000 person-hours.

**Shims.** Steel strips used during brick installation.

**Shotcrete.** Refractory concrete shot through a nozzle with a set accelerator.

**Silicon carbide.** Synthetic material of composition SiC.

**Slag.** By product from blast furnace and steel production. Contains lime, silica, alumina and iron.

**Slaked lime.** Calcium hydroxide that is produced by the chemical reaction of quicklime with water.

**Slurry.** Suspension of ground raw materials in water.

**Snowman.** Formation of sticky, fine, clinker buildup in clinker cooler, following discharge from a rotary kiln.

**Solvent.** A substance that can dissolve another material.

**SPC.** Statistical Process Control.

**Spinel.** Family of minerals of empirical formula RO·R_2O_3. Example: MgO·Al_2O_3.

**Stage.** Different cyclones in a preheater tower.

**Structural spalling.** Spalling caused by a change in brick composition.

**Sulfur cycle.** Process whereby sulfur, introduced into the kiln, is in part internally recycled by evaporation and condensation processes.

**Sulfur speciation.** The form in which sulfur is combined, e.g., as SO_2 in the vapor phase.

**Superordinate control.** Plant control of subprocesses and sensors used directly in the process

**Switch.** Similar to a hub, but with some intelligence, used to more efficiently transfer information to the intended address on the network.

**Systemic poison.** A substance than can spread throughout the body, causing damage to multiple organs or bodily systems.

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**TCP/IP.** Transmission Control Protocol/Internet Protocol. A commonly used communications protocol developed to convey packets of information that developed into the Internet.

**Teratogen (also called mutagen).** A substance that can alter a cell’s genetic information and lead to undesirable inherited conditions.

**Terminal.** Device used to enter/receive information from a computer.

**Tertiary air.** Hot air bypassed from the hood or cooler to the precalciner.

**Theoretical combustion temperature.** A calculated flue gas temperature of combustibles, which is calculated from their composition and heat content.

**Thermal shock.** A sudden change in temperature.

**Thermal spalling.** Damage caused by a thermal shock.
**Thin client.** Refers to a low-cost, centrally-managed computer devoid of CD-ROM players, diskette drives, and expansion slots. The term derives from the fact that small computers in networks tend to be clients and not servers, since the idea is to limit the capabilities of these computers to only essential applications, they tend to be purchased and remain "thin" in terms of the client applications they include.

**Threshold limit value (TLV).** The airborne concentration of a substance to which workers can be exposed without harmful effect, for 8 hours per day for the duration of one's work career.

**Tires.** Supporting steel rings around the kiln shell.

**Toxic.** The ability of a substance to cause harm to the body or its systems.

**Toxicity.** The ability of a substance to injure a bodily organ or system, interrupt a biochemical process or affect an enzyme system.

**Trace components.** See minor elements.

**Tumbler.** Refractory or metal device to tumble the kiln load.

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**U**

**Ultraviolet.** Radiation above the visible light spectrum with wavelengths shorter than violet light.

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**V**

**Valve bag.** Cloth or paper sack for cement that is completely closed except for a self-sealing valve through which the cement is introduced at the packing machine.

**Vapor.** The gaseous state of a substance that is a solid or liquid under normal conditions of temperature and pressure.

**Vapor-liquid equilibria.** A chemical equilibrium, at its simplest, between one liquid and one gas phase; for example, between molten K$_2$SO$_4$ and a vapor containing K$_2$SO$_4$ and its dissociation products.

**VDZ.** Abbreviation for Verein Deutscher Zementwerke, the German Association of Cement Works.

**Volatile components.** A substance whose vapor pressure is substantial in the kiln and is thus prone to evaporation.

**Volatilization.** The process of driving out and vaporizing the alkalies (or other materials) from cement raw material during the burning process. Effective volatilization depends on temperature, thickness of bedding, size of nodule, and time.

**Volatile cycle.** In the kiln, a cycle that develops due to volatilization and condensation of lower boiling compounds such as chlorides, sulfates and alkalies.

**Volatileies.** Typically (but not exclusively) alkalies, sulfur, and chlorine in circulation.

**Volume element.** Volume on a microscopic scale of clinker small enough for the phase composition to be in accordance with the phase diagram for that specific composition and temperature.

**Vortex finder.** Cyclone thimble.

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**W**

**WAN.** Wide Area Network. A network of computers located on many sites.

**Wet bulb globe temperature (WBGT).** A thermal index that combines air temperature, radiant heat, humidity and air movement.
X

**X-ray fluorescence analysis.** Determination of elemental composition of a sample by identification and measurement of secondary or characteristic radiation’s caused by exposing a sample to high energy x-rays.

**XRD.** X-ray diffraction spectrometry.

**XRF.** X-ray fluorescence spectrometry.

Z

**Zircon.** Zirconium silicate.

**Zirconia.** Zirconium oxide.

**Zoonoses.** Diseases of animals that may be transmitted to humans.