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GLOSSARY

Absorbance: Measure of concentration of material present: negative log (base 10) of Transmittance [log 1/T]. Product of extinction coefficient, path-length, and concentration, written as A = E bc.

Absorption: The reduction in intensity of a beam of electromagnetic radiation as it passes through matter, chiefly due to interactions with atoms or electrons, or with their electric and magnetic fields.

Absorption Spectroscopy: The study of the wavelengths of light absorbed by materials and the relative intensities at which different wavelengths are absorbed. This technique can be used to identify materials and/or measure their concentration.

Absorptivity: Probability of light absorbing at a particular wavelength for a specific analyte under specific conditions, e.g., pH, temperature, etc. Thus, a specific amount of material at specified conditions, will absorb a specific fraction of the light striking it. Absorptivity is signified by an epsilon or a small "a".

Accuracy: Nearness of a measurement to its true or accepted value.

Acidity: Represents the amount of free carbon dioxide mineral acids and salts (especially sulfates of iron and aluminum) which hydrolize to give hydrogen ions in water and is reported as milliequivalents per liter of acid, or ppm acidity as calcium carbonate.

Acousto-Optic: An interaction between an acoustic wave and a lightwave passing through the same material. Acousto-optic devices can serve for beam deflection, modulation, signal processing and Q switching.

Adsorption: The phenomena of molecules of one or more specific elements or compounds concentrating at the phase boundary, usually at a solid surface, contacting a fluid containing the specific element or compound.

Aliquot: an exact known portion of a whole quantity. Often used where weighing of individual small samples might introduce error into the analysis. Weigh a large sample, dilute this sample to a known large volume, titrate a known portion (aliquot) of that large volume.

Alkalinity: Represents the amount of carbonates, bicarbonates, hydroxides and silicates or phosphates in the water and is reported as grains per gallon, or ppm, as calcium carbonate.

Ambient Temperature: The uncontrolled temperature existing in immediate surroundings.

Analyte: The particular material or quality to be determined by analytical analysis.

Analyzer Flow: This is the sample flow (take off from the fast loop) that is delivered to the analyzer for specific component analysis or physical property determination.

Analyzer Project: An analyzer project is the design and installation of multiple analyzer systems, which may involve analyzer enclosures or shelters.

Analyzer Systems: A Process Analyzer System consists of an analyzer, a sample transport system, a sample conditioning system, a calibration system and one or more readout devices. These are designed and assembled to automatically take a representative sample of a process stream and to identify and measure specific component concentrations in it or physical properties of it.

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Analyzer System Fast Loop: A part of the sample transport system that is designed to bring the process sample close to, but not through, the analyzer. The purpose is to reduce the time lag in getting sample from the process tie point. The term bypass sample line is sometimes used to define the same part of the system.

Area Classification: The classification of general purpose and hazardous area locations by Class (I, II or III) depending upon the presence of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings and by Division 1 or 2 depending upon the probability of these materials existing in an ignitable concentration under normal or abnormal conditions.

Area Classification (Class):

1. Class I locations are those in which flammable gases or vapors are, or may be, present in the air in quantities sufficient to produce explosive or ignitable mixtures.
2. Class II locations are those that are hazardous because of the presence of combustible dust.
3. Class III locations are those that are hazardous because of the presence of easily ignitable fibers or flyings, but in which such fibers or flyings are not likely to be in quantities sufficient to produce ignitable mixtures.

Area Classification (Division):

1. Division 1 (hazardous). Where concentrations of flammable gases or vapors exist (a) continuously or periodically during normal operations; (b) frequently during repair or maintenance or because of leakage; or (c) due to equipment breakdown or faulty operation which could cause simultaneous failure of electrical equipment.
2. Division 2 (normally non-hazardous). Locations in which the atmosphere is normally non-hazardous and may become hazardous only through the failure of the ventilating system, opening of pipe lines, or other unusual situations.

Area Classification (Group): Identified groups of chemicals and compounds whose air mixtures have similar ease of ignition and explosive characteristics. Group A atmospheres contain acetylene. Group B atmospheres contain butadiene, ethylene oxide, propylene oxide, acrolein, or hydrogen (or vapors equivalent in hazard to hydrogen). Group C atmospheres contain cyclopropene, ethyl ether, ethylene, or vapors of equivalent hazard. Group D atmospheres contain acetone, alcohol, ammonia, benzene, benzol, butane, gasoline, hexane, lacquer solvent vapor, naphtha, natural gas, propane, or vapors of equivalent hazard. Group E atmospheres contain metal dusts. Group G atmospheres contain combustible dusts having resistivity of $>10^5$ ohm-cm^2.

Aspirate: To draw out, by suction.

At-Line: Analyzers located at the process unit that have capability of conditioning and analyzing manually collected samples that are brought to them.

Availability %: The percentage of time that the analyzer is meeting its accuracy expectations. Availability is calculated by subtracting from the time the process unit is operating (TT) all time that the analyzer is logged to be in calibration, down for repair or out of service (TOS) for any reason and divided by unit operating time with an automatic calculation that subtracts time from the availability if validation finds the analyzer out of calibration. (fTFV)

$$\%\ \text{Availability} = \frac{\text{TT} - \text{TOS} - \text{fTFV}}{\text{TT}} \times 100$$

Backflush: Analytes flushed out of the column to vent or to another column by flow reversal.

Background: Constituents in the sample or space to be tested other than the specific analyte being measured.

Baum'e Scale: Either of two specific gravity scales devised by French chemist Antoine Baum'e in 1768 and often used to express the specific gravity of acids, syrups and other liquids; for light liquids the scale is determined from the formula: °B'e = (140/sp. gr.) – 130. For heavy liquids it is determined from: °B'e = 145 – (145/sp. gr.). 60°F is the standard temperature used.

Beam Splitter: A device which separates a light beam into two beams. Some types affect polarization of the beam.

Beer's Law: Relationship between the amount of light absorbed by an analyte and its concentration (c), pathlength (b), and absorptivity (a), expressed in kilograms per Liter or molarity, written as A = abc.

Benchmark: Performance indicator able to be compared from site to site, company to company and industry to industry.

Bias: A constant or systematic error.

Bleed: Loss of material from a column liquid phase or septum because of high-temperature operation. May result in ghost peaks and increased detector baseline offset and noise.

Bonded phase: A stationary phase that has been chemically or physically bonded to the inner column wall or stationary phase.

BTU: The mean British Thermal Unit is 1/180 of the heat required to raise the temperature of 1lb of

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water from 32°F to 212°F at a constant atmospheric pressure. It is about equal to the quantity of heat required to raise 1 lb of water 1°F. A BTU is approximately 252 calories.

Bubble Point: The temperature at which volatile species in a process stream will form gas bubbles at a specified pressure (usually atmospheric).

Bypass: See "Fast Loop".

Calibration and Automatic Calibration: Calibration is the introduction of a solution or "standard" of known concentration or property to the analyzer. The measured results are compared to the standard and the response factors of the analyzer are adjusted so the measured results match the standard. Automatic calibration is the same activity with no human intervention and is normally on a fixed time cycle.

Calibration Traceability: The relationship of the calibration of an instrument through a step-by-step process to an instrument or group of instruments calibrated and certified by a national standardizing laboratory. Note: The estimated error incurred in each step must be known.

Calorimeter:

1. A device for determining the amount of heat liberated during a chemical reaction, change of state or dissolution process.
2. Apparatus for determining the calorific value of a fuel.

Calibration Curve: The results of a calibration when graphed, usually on Cartesian coordinates, e.g., concentration versus absorbance.

Calibration Solution: A solution of known value of the property or concentration being measured. Used for periodic calibration and for various performance tests. Also known as a "standard".

Capacity Factor: k, a measurement of retention in a chromatographic process.

Carrier: Fluid that serves as both sample solvent/diluent and sample transport through a chromatographic column.

CEM: Continuous Emission Monitor.

CEQA: Cost per **EQ**uivalent **A**nalyzer. This indicator enables measurement of support system effectiveness.

$$\text{CEQA} = \frac{\text{Total Analyzer Repair Cost in Last 12 Months}}{\text{Average\# of Equivalent Analyzers in Last 12 Months}}$$

CGA:

1. Cylinder Gas Audit as pertaining to Federal Code governing CEMS.
2. Compressed Gas Association as pertaining to valve fittings on compressed gas cylinders and regulators.
3. Continuous Gas Analyzer.

Chromatogram: The pattern formed by the chromatograph output which represents zones of separated compounds on a time chart. The elution time of the peak and the area under the peak aid in identifying the component and its concentration.

Chromatography: An instrumental procedure for separating components from a mixture of chemical substances which depends on selective retardation by physical adsorption of substances on a porous bed of sorptive media as the substances are transported though the bed by a moving fluid. The sorptive bed (stationary phase) may be a solid or a liquid dispersed on a porous, inert solid.

Color: Measurement of absorbance of visible light that is indicative of product purity or uniformity.

Colorimetry: Any analytical process that uses absorption of selected bands of visible light, or some times ultraviolet radiation, to determine the concentration of a substance which absorbs the light. It can be used to detect the end point of a reaction.

Combustible Gas: A gas which has a low enough flash point and a wide enough explosive range to make it easily ignitable at ambient conditions.

Commissioning: This is a field demonstration of the operation of an analyzer system and all the associated hardware, software and peripherals. This activity will include demonstrating that all signals have the correct range and all alarms generates the correct sequence of operations and actions.

Concentration: The amount of specific substance in a given volume or mass of solution, e.g., moles per liter.

Control Chart: A plot of some measured quantity versus sample number or time which can be used to determine a quality trend or to make adjustments in process controls as necessary to keep the measured quantity within prescribed limits.

Control Limits: In statistical quality control, the upper and lower values of a measured quantity that establish the range of acceptability.

Coulometric Titration: A method of wet chemical analysis in which the amount of an unknown substance taking part in a chemical reaction is determined by measuring the number of coulombs of electricity required to reach the end point of the titration.

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Cross-linked phase: A stationary phase that includes cross-linked polymer chains; usually bonded to the column inner wall.

Cross-Sectional Sampling: Extracting samples from varying positions in the process stream.

Crosstalk: Contamination between process streams in a multi-stream sampling system because of poor isolation of the separate streams.

Cycle Time: Time it takes cyclic analyzers to update results of a specific sample.

Dalton's Law: A scientific principle that the total pressure exerted by a mixture of gases equals the sum of the partial pressures that would be exerted if each of the individual gases present were to occupy the same volume by itself.

Data Acquisition System (DAS): A system used for acquiring data from sensors via amplifiers and multiplexers and any necessary analog-to-digital converters.

Data logger:

1. A system or subsystem with a primary function of acquisition and storage of data in a form that is suitable for later reduction and analysis.
2. A computer system designed to obtain data from process sensors and to provide a log for the data. Many data loggers can carry out some filtering and linearizing of the data.

Dead volume: All volume in a sample system, such as a filter, or in an analyzer that contributes to a slower sample stream linear velocity than in the tubing through the system. For GC's it also includes all volume between injection device and the column that the sample passes through in a chromatographic system. Excessive dead volume causes additional peak broadening.

Detector: The sensing element of a device that generates a signal proportional to the concentration or property of interest.

Design Conditions of Operation: The extreme conditions which an operating instrument can withstand without resulting in damage or degradation of performance.

Dew Point: The temperature at which condensable gases in a process stream will form liquid droplets at a specified pressure.

Diffraction Grating: See "Grating".

Diffusion: In relation to gases, a spreading out and permeation of the space occupied. A diffusion gas detector is a sensing element which is exposed continuously to the atmosphere it is to monitor, and over which the sample flows by natural movement of the gas rather than by action of a pump.

Dilution: The act of reducing the concentration by adding other components. In the case of gas detection, a gas concentration can be weakened or diluted by the introduction of air.

Diode Laser Array: A device in which the output of several diode lasers is brought together in one beam. The lasers may be integrated on the same substrate, or discrete devices may be coupled optically and electronically.

Direct Injection: Sample enters the inlet and is swept into the column or detector by carrier gas flow. No sample splitting or venting occurs during or after the injection.

Discrete Sampling: Analysis of a small aliquot of sample diluted in a carrier fluid usually at a remote point.

Double Block & Bleed: Automatic venting between two block valves separating sample streams and/or calibration fluids.

Drift: The change of signal output from an analyzer, for a given value of the property being measured, over a stated period of time, under reference conditions which remain constant and without systematic error adjustment to the analyzer by external means.

Dry Basis: A method of expressing the composition of a sample on a moisture free basis.

Dual Beam Analyzer: A type of radiation-absorption analyzer that compares the intensity of a transmitted measurement beam with the intensity of a reference beam of the same wavelength.

Efficiency: The ability of a column to produce sharp, symmetrical peaks. More efficient columns have more theoretical plates of separation.

Electrochemical Analyzer: An instrument that provides an indication of a specific property of a medium by use of a sensor which responds to ions within (or from) that medium.

Electrode: A conductor by means of which a current passes into or out of a liquid or an insulating material. Their function is to pass current from the electrolyte to the instrument's meter.

Electrolyte: A substance which produces a conducting medium when dissolved in a suitable solvent, usually water. Potassium chloride used in some oxygen cells would be termed an electrolyte.

Electron-Capture Detector: An electron capture detector ionizes solutes by collision with metastable carrier gas molecules produced by beta-particle emission from a radioactive source such as Ni63. The electron-capture detector is one of the most sensitive detectors and responds strongly to halogenated

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compounds and other solutes with a high electron-capture cross section.

EQA: EQuivalent **A**nalyzer calculation attempts to equilibrate the complexity of the sites' analyzer population in order to enable benchmarking. The EQA inventory worksheet (attached) should include all permanently installed field analyzers.

EQAT: EQuivalent **A**nalyzers per **T**echnician is a Performance Indicator that enables identifying good work practices, training needs, and even poor performing analyzers, which are called bad actors. This equivalency system is also useful for zero-base budgeting manpower and setting work schedules.

$$\text{EQAT} = \frac{\text{Total Number of Equivalent Analyzers}}{\text{Total Effective Number of Technicians}}$$

Equivalency Factors: Factors for one analyzer, one detector, analyzing one stream, measuring one component or property. If a single analyzer is being used but has more than one detector, or more than one internal switching valve, or more than one stream or is measuring/predicting more than one component or property then the correction factors should be used to adjust the equivalent analyzer number.

Etalon: A type of Fabry-Perot interferometer in which the distance between two highly reflecting mirrors is fixed. It is used to separate light into different wavelengths when the wavelengths are closely spaced.

Explosion Proof Enclosure: An enclosure that is capable of preventing an explosion of a gas or vapor within it from igniting an explosive gas or vapor that may surround it.

Ex-situ: An analyzer that makes its measurement close-coupled to process apparatus.

Extinction/Extinction Coefficient: Words sometimes substituted for absorbance and absorptivity, respectively.

Extractive: Is when the measurement takes place remote from the process. It involves a sample system and sample transport system.

Factory Acceptance Tests (FAT): These are the acceptance tests that are performed at the Analyzer Manufacturer's facility.

Fail Safe Device: A component, system or control device so designed that it places the controlled parameter in a safe condition in case of a power interruption, controller malfunction or failure of a load-carrying member.

Fast Loop: High velocity, continuously operating sample loop bringing fresh sample in close proximity to the analyzer detector. Synonymous with "Bypass sample" or "Slip Stream".

Field Effect Transistor (FET): A semiconductor device having a conducting channel whose resistance is modified by the electrostatic field produced by an adjacent gate electrode.

Filament: The sensing element used in a thermal conductivity detector, usually in the form of a coil of platinum wire.

Flame Arrestor: Used in combustible gas detection, a porous barrier for the catalytic filament in an instrument operating on the oxydation reaction principle. The flame arrestor is often made of fire resistant porous material, such as sintered bronze, stainless steel, or monel and its purpose is to contain any flame which may result from combustible gas mixture passing over the heated catalyst.

Flame Ionization Detector: A flame ionization detector measures the ionized molecules produced from hydrocarbon-containing solutes in a hydrogen-air flame. The flame ionization detector is a nearly universal detector that responds proportionately to the concentration of the analyte.

Flame Photometer: An instrument for determining compositions of solutions by spectral analysis of the light emitted when the solution is sprayed into a flame.

Flame Photometric Detector (FPD): The flame photometric detector burns solutes in a hydrogen-air flame. The visible range atomic emission spectrum is filtered through an interference filter and detected with a photo-multiplier tube. Different interference filters may be selected for sulfur, or phosphorus emission lines. The photometric detector is sensitive and selective.

Flash Point: The temperature of a liquid, at a given pressure, at which it gives off vapor sufficient to form an ignitable mixture with the air near the surface of the liquid or within the vessel used.

Fluorescence Spectroscopy: The study of materials by the light which they emit when irradiated by other light. Many materials emit visible light after they have been illuminated by ultraviolet light. The intensity and wavelengths of the emitted light can be used to identify the material and its concentration.

Flush: In combustible gas analysis, this term is used to signify clearing the instrument of all residues of gases from previous samplings and is accomplished by drawing atmospheric air through the instrument until a zero response reading is obtained.

FM: Factory Mutual. A combination of insurance companies who have formed a testing and approval

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agency for fire protection and other industrial safety equipment. Products in this category submitted to them are tested for safety in performance and if accepted are listed as approved and marked with the FM approval stamp.

Frequency: The number of times per unit time that the magnitude of an electromagnetic wave goes from maximum to minimum then back to maximum amplitude. The unit for the number of waves per second is Hertz (Hz).

Gamma Ray:

1. Electromagnetic radiation emitted by the nucleus of an atom, each photon resulting from the quantum transition between two energy levels of the nucleus.
2. A term sometimes used to describe any high-energy electromagnetic radiation, such as x-rays exceeding about 1 MeV or photons of annihilation radiation.

Gas Chromatography: Solutes partition or separate by adsorbing and desorbing between a mobile gaseous phase and a liquid or solid stationary phase. Selective interactions between the solutes and the liquid phase or solid stationary phase in the column result in different solute retention times (peaks).

Ghost peaks: Peaks, in gas chromatography, caused by substances not present in the original sample. Ghost peaks can be caused by septum bleed, solute decomposition, or carrier-gas contamination.

Grating: A reflective surface covered (or imbedded in a hologram) with evenly spaced, microscopic grooves whose purpose is to separate the individual wavelengths from "white" light. The distance between grooves and the angle of the faces are determined by the wavelengths to be separated. The grating (except for diode arrays) is rotated at a set speed and the desired wavelength is emitted through an exit slit onto the sample or standard.

Gravimetric: A descriptive term used to designate an instrument or procedure in which gravitational forces are utilized.

Gross Calorific Value: The defined empirical measurement of the heat value or energy per unit volume at standard conditions and expressed in terms of British thermal units per standard cubic feet (BTU/SCF) or kilocalorie per cubic Newton meters ($Kcal/Nm^3$) or other equivalent units.

Ground Loop: Circulating current between two or more connections to electrical ground. This signal can be detected and displayed by electronic instruments. These signals are generally not associated with the variable to be measured and represent noise in the measuring system.

Hall Detector: A Gas Chromatographic detector particularly sensitive to halogens like chlorine.

Headspace Sampling: Gas-phase sampling technique in which solute is removed from an enclosed space above a solid or liquid sample.

Heat Tracing: The technique of adding heat to a sample measurement line by placing a steam line or electric heating element adjacent to the line.

Heartcut: Two or more partially-resolved peaks eluted from one column are directed onto another column of different separating characteristics, or at a different temperature, for improved resolution.

Henry's Law: A principle of physical chemistry that relates equilibrium partial pressure of a substance in the atmosphere above a liquid solution to the concentration of the same substance in the liquid; the ratio of concentration to equilibrium partial pressure equals the Henry's law constant, which is a temperature-sensitive characteristic. Henry's law generally applies only at low liquid concentrations of a volatile component.

Histogram: A type of SQC chart that is a graphic representation of a distribution function by means of rectangles whose widths represent intervals into which the range of observed values is divided and whose heights represent the number of observations occurring in each interval.

Hygroscopic:

1. Material that will readily absorb and retain moisture [API RP60.11].
2. Having a tendency to absorb water [ISA S71.04]. Having the ability to accelerate the condensation of water vapor. Dry material having the ability to absorb water vapor from the surrounding atmosphere.

Hysteresis: The difference in indicated value from the current actual value of the property being measured due to an artificial lag possibly due to an averaging affect.

Ideal Gas: A hypothetical gas characterized by its obeying precisely the equation for a perfect gas, $PV = nRT$.

Infrared (IR): Any electromagnetic wave whose wavelength is 0.78 to 300 μm (0.00078 to 0.300 nm).

Infrared Spectroscopy: A technique for determining the molecular species present in a material, and measuring their concentrations, by detecting the characteristic wavelengths at which the material absorbs infrared energy and measuring the relative

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drop in intensity associated with each species' absorption band.

In-line Analysis: The analytical probe is placed directly in the process stream with no need for extractive sampling. Also called in-situ.

In-situ: Analyzer makes its measurement within the process line or operating equipment.

Interference: The distortion or inaccuracy of a measurement usually due to the presence of compounds that affect the detector in a manner very similar to the analyte.

Intrinsically Safe: This is a term applied to an instrument or device which is incapable of becoming a source of ignition due to the low energy available from its electrical circuits. Many applications exist where the atmosphere is so hazardous that no possible source of ignition can be allowed. Instrumentation used in such a location may have to be approved by one of the approval agencies (FM or UL) as "intrinsically safe".

Isokinetic Sampling: In-line sampling where the velocity of the process stream is the same as the velocity of the material removed for analysis.

Isothermal: Operating at constant temperature.

Joule-Thompson Effect: A change in gas temperature when the gas pressure is reduced by expansion through an orifice. Most gases exhibit a temperature decrease when this occurs.

KPI: Key Performance Indicator or performance index.

Lag Time: Time it takes fresh sample to reach the analytical measurement cell from the process line.

Laminar Flow: Flow through piping or tubing with little or no mixing. The velocity of the material in the pipe or tube is in the direction of flow with very little perpendicular component.

Limit of Detection: Lowest amount of analyte that may be measured. Usually 2 times the noise level of the instrument.

Linearity: The response of an instrument changes in a linear or proportional fashion with increasing analyte concentration.

Linear Range: Also, linear dynamic range. The range of solute concentration or amount over which detector response per solute amount is constant within a specified percentage.

Linear Velocity *u*: The speed at which carrier gas moves through the column.

Liquid Phase: In GC, a stationary liquid layer coated on the inner column wall (wall-coated open-tubular column [WCOT]) or on a support (packed, support-coated open-tubular column [SCOT]) that selectively interacts with different solutes to produce different retention times.

Lower Explosive Limit (LEL): The minimum concentration of a combustible gas mixed with air, where an explosion may occur. This concentration is expressed in % of volume. For combustible gas instruments used to detect explosive atmospheres, the concentration is expressed as a percentage factor of the LEL point. A reading of 100% LEL corresponds to the % volume concentration where LEL occurs.

Mass Spectrometer: An electronic instrument able to measure mass distribution of ions in the separated ion beam.

Membrane: An inert material that has pores of uniform size. These pores allow the transfer of molecules in the gas state. Generally, the transfer of liquids is inhibited due to agglomeration of molecules caused by surface tension.

Method Detection Limit (MDL): The amount of solute that can be analyzed within specified statistical limits, including sample preparation.

Minimum Detectable Limit (MDL): The change in value of the property to be measured equivalent to twice the baseline fluctuation.

Miscible: Solubility of two liquids, one in the other.

Moles: The weight of the component divided by its molecular weight.

Molecular Sieve: Stationary phase that retains solute by molecular size interactions.

Monochromator: An optical device which uses a prism or diffraction grating to spread out the spectrum, then passes a narrow portion of that spectrum through a slit; this generates monochromatic light from a nonmonochromatic source.

Multidimensional: Separation performed with two or more columns in which analytes are selectively directed onto or removed from at least one of the columns by use of a timed-valving system. See backflush, heartcut, precut.

Multi-stream Sampling: The use of parallel sample flow paths and isolation valving to provide analytical results for more than one process stream using a single analyzer.

National Electrical Code (NEC): A set of standards governing design and installation of electrical equipment in the USA to ensure safe installation. The National Electrical Code is maintained and periodically reviewed by a committee of the National Fire Protection Association (NFPA).

National Fire Protection Association (NFPA): A nonprofit membership organization whose aims are to improve methods of fire protection and prevention,

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to publish information on these subjects, and secure the co-operation of its members and the public in establishing proper safeguards against loss of life and property by fire.

Nephelometer: A general term for instruments that measure the degree of cloudiness or turbidity at 90 degrees to the axis of the light (cf. turbidimeter).

Nernst glower: Radiation source for infrared spectrophotometers. The Nernst glower is a hollow rod of mixed zirconium/yttrium oxides which, when heated to 1500°C (2732°F) by an applied electric current, emits radiation in the range 0.4 to 20 μm. The Globar is a pure silicon carbide rod which, when heated to 1200°C (2192°F) by an applied electric current, emits radiation in the range 1 to 40 μm. The Globar is a more stable source than the Nernst glower.

Net Calorific Value: The measurement of the actual available energy per unit volume at standard conditions, which is always less than the gross calorific value by an amount equal to the latent heat of vaporization of the water formed during combustion.

Noise: Any signal generated by the detector not directly related to a change in concentration of the solute.

Non-hazardous Area: An area in which explosive gas/air mixtures are not expected to be present so that special precautions for the construction and use of electrical apparatus are not required.

Non-incendive: Equipment and wiring which in its normal operating condition is incapable of igniting a specific hazardous atmosphere or hazardous dust layer. Equipment and wiring have exposed blanketed surface temperatures above 80 percent of the ignition temperature in degrees Celsius of the specific hazardous dust layer shall not be classed as non-incendive. The blanketed surface temperature shall be determined at the outside surface of the enclosure beneath the surface of a dust accumulation 0.2 inch or more in thickness.

Nitrogen-Phosphorus Detector: The nitrogen-phosphorus detector catalytically ionizes nitrogen or phosphorus containing solutes on a heated rubidium or cesium surface in a reducing atmosphere. Nitrogen-phosphorus detectors are highly selective.

Offline: Analyzers in a laboratory.

Online: Analyzers tubed to the process and continuously obtaining fresh sample.

Optical Bench: A rigid horizontal bar or track for holding and supporting optical devices in fixed positions, yet allowing the positions to be changed or adjusted quickly and easily.

Optical Emission Spectrometry: Measurement of the wavelengths and intensities of visible light emitted by a substance following stimulation.

Optical Filter: A semi-transparent device that selectively passes rays of light having predetermined wavelengths.

Output:

1. The power, current or voltage delivered by a circuit or device.
2. The terminals where the power, voltage or current will be delivered.
3. Display of measurement.

Path Length: The distance the light passes through the sample in its holder. For single path spectrometers it is the inside dimension of the measuring cell. For multi-path spectrometers it is the inside length of the cell multiplied by the number of times that the radiation reflects back and forth in the cell.

Packed Column: A chromatographic column filled with particles of porous substrate.

Partial Pressure: The portion of total pressure in a closed system containing a gas mixture that is due to a single element or compound.

Parts per Million: A unit of measurement used for small proportions or concentrations. In gas analysis, it expresses the volume of a gas present in terms of its relationship to a whole of 1 million parts of air. 1% = 10,000 ppm. 1% of volume = 10,000 ppm, 100% of volume = 1,000,000 ppm.

Peak Amplitude: Height of spikes off of a baseline of a chromatographic or optical trace.

Peak Area: Area under the peak of a chromatographic or optical trace.

Peak Capacity: The amount of solute that can be injected without significant loss of column efficiency or overloading of column.

PEMS: Predictive Emission Monitoring Systems; normally do not use analytical detection hardware.

Performance Characteristic: One of the quantities assigned to an apparatus in order to define its performance by values, tolerances, ranges, etc.

Permeability: The quality or condition of allowing passage, especially of liquids and gases through a membrane.

pH: The symbol for the measurement of hydrogen ion concentration. Solutions with a pH reading of less than 7 are acid; solutions with a pH reading of more than 7 are alkaline on the pH scale of 0 to 14 where the midpoint of 7 is neutral.

$$-\log_{10}[H+]$$

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Phase:
1. Physical state of a pure compound; vapor, liquid or solid.
2. As applied to AC power sources, refers to the number and relationship of alternating voltage supplied. Single phase (2 wire) power is always used for lighting, instrumentation, and all small power loads. Three phase (3 wire) power is used primarily for larger motors, as it makes it possible to use simpler, more efficient motor construction. Single phase power can always be obtained between any two wires of a three phase system.

Photo-Ionization Detector (PID): The photo-ionization detector ionizes solute molecules with photons in the UV energy range and then measures the amounts of the various ions.

Poisoning: The desensitizing action of certain molecules on the detection element. An example of this is the sensitivity loss which occurs on a platinum filament in the presence of silicone vapors.

Polarizing Filter: Semi-transparent material that transmits light polarized in one plane and blocks light polarized orthogonally to that plane.

PONA Analysis: Determination of amounts of paraffins (P), olefins (O), naphthalenes (N) and aromatics (A) in a hydrocarbon sample.

Porous-Layer Open-Tubular Column (PLOT): A capillary column with a modified inner wall that has been etched or otherwise treated to increase the inner surface area and provide gas-solid chromatographic retention behavior.

Precipitate:
1. To separate materials from a solution by formation of insoluble matter by chemical reaction.
2. The solid insoluble material which is removed.

Precision: See Repeatability.

Precut: Analytes eluted at the beginning of a run are removed to vent or directed onto another column of different chromatographic retention, or at a different temperature for improved resolution.

Preventive Maintenance: Proactive maintenance specifically extended to prevent faults from occurring during subsequent operation. Corrective maintenance or "catastrophic maintenance" proceeds after the fault has occurred.

Probe: A device that provides for the extraction of a representative sample of the process stream (usually from the centroid) for analysis. Or an in-line device that provides a direct reading of the process stream.

Programmed-Temperature Chromatography: A technique in which the column is ramped from low to high temperatures to enable separation of the front end components of a high vapor pressure sample or faster separation of high boiling components.

Prototype: A model built to prove a design.

Purge: A flushing out of the sample drawing system with a fluid to remove all traces of previous samples. Instrument should zero when properly purged.

Purging Classifications:
1. Type Z purging. Covers purging requirements adequate to reduce the classification of the area within an enclosure from Div. 2 (normally non-hazardous) to non-hazardous.
2. Type Y purging. Covers purging requirements adequate to reduce the classification of the area within an enclosure from Div. 1 (hazardous) to Div. 2 (normally non-hazardous).
3. Type X purging. Covers purging requirements adequate to reduce the classification of the area within an enclosure from Div. 1 (hazardous) to non-hazardous (unclassified).

QAP: Quality Assurance Procedures.

Quadrupole Mass Spectrometer: A type of mass spectrometer employing a filter consisting of four conductive rods electrically connected in such a manner that, by varying the absolute potential applied to the rods, all ions except those possessing a specific mass-to-charge ratio are prevented from entering the detector.

Quality Assurance (QA): A set of systematic actions intended to provide confidence that a product or service will continually fulfill a defined need.

Quality Control (QC): A set of systematic actions that make it possible to measure significant characteristics of a product or service and to control the characteristics within established limits.

RAA/RATA: Relative Accuracy Audit/Relative Accuracy Test Audit.

Radiation Detector: Device used to detect the intensity of the radiation from either sample or reference beams. Usually a simple silicon diode or a more sensitive photo-multiplier tube for optical radiation. There are also specific radiation detectors for nuclear radiation like Gamma, Beta and X-rays.

Range: The domain between the upper and lower limits of the quantity under consideration.

Rated Operating Conditions: A set of operating ranges for pressure, temperature, flow, etc, within which the instrument can operate as specified by the manufacturer.

Reference Measurement: Measurement of everything that is in the sample light path except the analyte of

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interest; cell windows, solvent, and any buffer or matrix used to prepare the sample.

Reference Standard: Analyte wherein the purity is documented and used to construct a calibration curve.

Refractive Index: When light travels from one medium (fluid) to another (air to water), it undergoes a change in velocity, and if the angle of incidence is not 90 degrees, a change in direction. For a given interface angle, temperature and wavelength of light the amount of deviation or refraction will depend on the composition of the fluid.

Relative retention: r, for peak i, relative to standard peak s:

$$r = \frac{k_i}{ks}$$

Repeatability: Normal tolerance between repetitive analyses on same sample by one analyzer (this is similar to precision).

Reproducibility: Normal tolerance between two analyzers on same sample.

Resolution: The quality of separation of two peaks of a chromatogram or multiple absorption peaks of an optical spectra. A resolution of ≈1.5 is said to be "baseline" resolution. Incorporates both efficiency and separation.

Response: An indication on the readout device resulting from a change in the composition of the mixture being sampled.

Response Time: Time required for detector and or analyzer to reach full output after sample change.

Response Time 90% (T_{10}): The time interval from the instant a step change occurs in the value of the property being measured to the instant when the change in indicated value passes (and remains beyond) 90% of its steady-state amplitude difference, that is, $T_{90} = T_{10} + T_r$ (or T_f). In cases where the rising and falling response times differ, the different response times should be specified.

Retention time: The time for a peak to pass through the column from injection to the detector.

Rotameter: A variable-area, constant-head, indicating-type rate–of–flow volume meter in which fluid flows upward through a tapered tube, lifting a shaped plummet to a position where upward fluid force just balances the weight of the plummet.

Sample: A representative portion of the atmosphere or process being tested or a fixed amount of solute taken for analysis.

Sample Inlet: The opening in a sample drawing instrument to which the hose or tubing carrying the sample is attached and by means of which the sample reaches the detection assembly.

Sample Recovery System: System that recovers spent sample and returns it to the process.

Sample Frequency: The rate at which samples are withdrawn from the process stream or the rate at which a process analyzer provides an analytical result.

Sample System: System that conditions the representative sample enough to enable the analyzer to reliably perform its application unattended.

Sample Tap: The point where the sample line taps into the process line (pipe, duct, container) and the point where sample flow begins. It may also be referred to as "sample connection", "sample nozzle", or "process tap".

Scanning: The process where the wavelength range of the system is viewed in order, usually from lowest to highest wavelength. This usually occurs when the grating is rotated about its axis.

Selectivity: The ability of an analyzer to differentiate between two very similar substances based on their chemical characteristics.

Sensitivity: Degree of detector response to a specified solute amount per unit time or per unit volume.

Sensor: That part of the analyzer (which may be a separate unit), which is in contact with the sample and is making the measurement. Also called detector.

Separation: The degree of separation of two peaks in time. See *Resolution*.

Sigma: Statistical term that quantifies the distribution of data. One sigma defines the spread of data falling within 68.3% of the total centered about the mean. Two sigma encompasses 95.5% of the data and three sigma encompasses 99.7%.

Signal: The output of the detector due to its response to a physical or chemical property.

Signal-to-Noise Ratio: The numerical ratio of the total signal to the noise.

Simulator: A device which provides well-defined electrical properties, similar to a specific type of sensor.

Site Acceptance Test (SAT): This is the transfer of ownership of an analyzer system following a defined period of uninterrupted, on-line operation within acceptable performance parameters.

SMV/TMV: Scheduled **M**anual **V**alidations/**T**otal **M**anual **V**alidations is aimed at optimizing site resources and data quality through preplanning.

$$\text{SMV/TMV} = \frac{\text{Total Number of Scheduled Manual Validations}}{\text{Total Number of Manual Validations Performed}}$$

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Solutes: Chemical substances (sample) that are separated by an analyzer prior to measurement.

Solvent Flushing: A column-rinsing technique intended to remove nonvolatile sample residue and partially restore column performance. Also is used in some sample systems to help clean them up.

Source: This is the origin of the light used in the spectrophotometer, example: a Nernst glower or Globar for infrared light, an incandescent wire for visible light, a deuterium gas discharge for ultraviolet light.

Span: Sometimes the difference between the upper and lower limits of the quantity under consideration. More usually, the upper limit of the transmitted signal.

Sparging: An inert gas is bubbled through a sample in order to entrain volatile species in the gas. This gas is then sent to the process analyzer for analysis.

Split Injection: Sample size is adjusted to suit capillary-column requirements by splitting off a major fraction of sample vapors at the inlet so that as little as 0.1% enters the column. The rest is vented.

Splitless Injection: Derivative of split injection. During the first 0.5 to 4 minutes of sampling, the sample is not split and enters only the column. Splitting is restored afterward to purge sample remaining in the inlet. As much as 99% of sample enters the column.

Spectrum: Series of wavelengths of radiation, belonging to a specific portion of the electromagnetic continuum, e.g., the visible spectrum, where the "colors" are viewed in increasing wavelength. For the visible portion of the continuum the colors are red, orange, yellow, green, blue, indigo, and violet (ROYG.BIV!).

Statistical Quality Control (SQC): This is a collection of quantitative data that is subjected to analysis, interpretation and presentation to determine if it is meeting performance specifications. With an analyzer system the data is usually the following:

- — Measurement precision or repeatability—presented in the form of a normal distribution curve.
- — Calibration or validation response factors—presented as a control chart with upper and lower confidence limits.
- — Service factor or performance—presented as a percentage of the time that the analyzer system was available or utilized.

Standard Deviation (STD DEV): The positive square root of the expected value of the square of the difference between a random variable and its mean. Normally considered to be 2 sigma or 95% confidence level.

Stationary Phase: Liquid or solid material coated inside a column or on a packing that selectively retains solutes.

Startup: The first demonstrated operation of the analyzer system(s) on actual process samples.

Stray Light: Any radiation reaching the detector that is not emitted from the sample or the source at the chosen wavelength.

Support-Coated Open-Tubular Column (SCOT): A capillary column in which stationary phase is coated onto a support material that is distributed over the column inner wall. A SCOT column generally has a higher peak capacity than a wall-coated open-tubular column (WCOT) with the same average film thickness.

System Integrator Acceptance Test (SIAT): These are the tests that are performed at an Analyzer System Integrator's (ASI) facility after complete fabrication and assembly of the analyzer system(s).

Theoretical Plate: A hypothetical entity used to evaluate the efficiency of a column that exists by analogy to a multi-plate distillation column. As solutes migrate through the column, they partition between the stationary phase and the carrier gas. Although this process is continuous, a stepwise model is often visualized. One step roughly corresponds to a theoretical plate.

Thermal conductivity detector: A thermal conductivity detector measures the differential thermal conductivity of carrier-gas and reference-gas flow. Solutes emerging from a column change the carrier-gas thermal conductivity and produce a response. The thermal conductivity detector is a universal detector with moderate sensitivity.

TLV: Threshold Limit Value. The maximum concentration of a substance to which a workman may be exposed without ill affects during a normal 8 hour, 5 day week. The commonly accepted values are found in the set of guidelines published by the American Conference of Governmental Hygienists to indicate limit of safe level of airborne concentrations of toxic substances.

TLV-STEL: Threshold Limit Value-Short Term Exposure Limit. A 15-minute, time-weighted average exposure that should not be exceeded at any time during a work day, even if the 8-hour time-weighted average is within the TLV. Exposures as the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There

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should be at least 60 minutes between successive exposures at the STEL.

TMV/EQA: **T**otal **M**anual **V**alidations per **EQ**uivalent **A**nalyzer is a good indicator of system automation and will drive your site towards greater automation. This KPI also gives an indication of customer satisfaction, whether the site is automated or not.

$$\text{TMV/EQA} = \frac{\text{Total Number of Manual Validations in Last 12 Months}}{\text{Average No. of Equivalent Analyzers in Last 12 Months}}$$

TOC: Usually, Total Organic Carbon, sometimes, Total Oxidizable Carbon.

TOD: Total Oxygen Demand.

Total Effective Technician Number: Number of technicians utilized to maintain all assigned analyzers. This should include permanent maintenance staff dedicated to analyzers, permanent maintenance staff who have instrument and analyzer responsibilities, long time contractors, ongoing contracted maintenance services and any analyzer work done by multi-craft personnel (i.e., Operations staff doing analyzer validation).

Toxic: Poisonous. In industrial health, toxic is defined as having some adverse effect under some conditions of exposure.

Transmittance: Ratio of the radiation transmitted by a sample to the radiation transmitted by a blank in an equivalent cell.

Transport Time: The time required for the sampling system to move an aliquot of the process stream to the process analyzer.

Turbidimeter: A general term for instruments that measure the degree of cloudiness or turbidity along the axis of the light (cf. nephelometer).

Turbulent Flow: Flow through piping characterized by direction changes in velocity and good mixing.

TWA: Time weighted average usually for 8 hour day.

UCL/LCL: Upper/Lower Control Limit of an SQC chart.

Ultraviolet Radiation (UV): Electromagnetic radiation having wavelengths shorter than visible light and longer than low frequency x-rays. Wavelengths of about 14 to 400 nanometers.

Ultraviolet Spectroscopy: Determination of the concentration of various compounds in a water solution or gas stream based on characteristic absorption of ultraviolet radiation; UV absorption patterns are not as distinctive "fingerprints" as their IR counterparts, but in many cases the former are more selective and sensitive for use in process control applications.

Underwriters Laboratories (UL): An independent testing and approval agency which examines electrically operated equipment and accessories, primarily from the standpoints of safety and freedom from hazards. Approved equipment is listed by UL and carries the UL label. A follow-up procedure assures that manufacturers do not make unapproved changes. UL does not have any connection with the Federal or other governments, but is recognized by many local government regulations which require UL labels on certain classes of electrical equipment.

Utilization: Percentage of time the analytical data is used for plant control performance "on computer control."

Validation and Automatic Validation: Validation is the introduction of a standard to the analyzer. The measured results are compared to historical data and reported, and the response factor is not changed. Automatic validation is the same activity with no human intervention and is normally on a fixed time cycle. Other terms commonly used for the above are "bench mark" and "check peak." When the historical data trend of a validation sample clearly exceeds the acceptable limit, the instrument should be calibrated.

Vapor: Any substance in the gaseous stage which at ordinary conditions is usually a liquid or a solid; a gasified liquid or solid.

Vent: An opening, usually small, for passage of fluids, gases, etc.

Visible: The portion of the electromagnetic spectrum detectable by human eyes. The portion of the spectrum from 350 to 780 nm.

VOC: Volatile organic carbon.

Wall-Coated Open-Tubular Column (WCOT): A capillary column in which the column wall is coated with stationary phase.

Warm-up Time: The time interval after switching on the power, under reference conditions, that is necessary for an analyzer to achieve a stable reading within specified limits of error.

Wavelength: The distance from one crest of an electromagnetic wave to the same position on the subsequent wave (Peak-to-peak distance), usually measured in nanometers.

Wet Basis: Calculating the stream composition with the moisture included as a component of the matrix.

Wheatstone Bridge: A four-leg electrical bridge circuit, in which all the legs are predominantly resistive, used

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for measurement of resistance. In gas detection instruments, an active and a reference filament usually occupy two legs of the bridge. The reference and two other resistive elements offer a fixed resistance while the active detection element acts as a variable resistance when exposed to a gas sample, thus unbalancing the bridge and giving a reading on the meter.

Wobbe Index: The ratio of the heat of combustion of a gas to the square root of its specific gravity. For light hydrocarbon gases the Wobbe index is almost a linear function of the gas' specific gravity.

X-rays: Short-wavelength electromagnetic radiation, having a wavelength shorter than about 15 nanometers, usually produced by bombarding a metal target with a stream of high energy electrons; wavelengths are in the same range as gamma rays, longer than cosmic rays but shorter than ultraviolet; like gamma rays, x-rays are very penetrating and can damage human tissues, induce ionization, and expose photographic films.

Zero: The term applied to the reference level of an instrument indicating no detection activity. This could be the "O" on a meter scale.

Zero Drift: The condition which occurs when the meter gradually shifts upscale or downscale when no solute (sample) is present.

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