



# X-RAY FLUORESCENCE (XRF):

## GLOSSARY – A GUIDE TO COMMON TERMS

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**Alloy** – A partial or complete solid solution of two or more elements in a metallic matrix, e.g., steel (Fe + C), brass (Cu + Zn), bronze (Cu + Sn).

**Alloy Grade** – The name or designation of an alloy with a particular composition, e.g., C377, Forging brass (Cu 58.0-62.0, Fe 0-0.3, Pb 1.5-2.5, Zn 35.2-40.5).

**Assay** – Qualitative or quantitative analysis of a metal or ore to determine its components.

**Atomic number** – Also sometimes called the proton number because it is equal to the number of protons in the nucleus of an atom e.g., Mg = 12, Fe = 26 and Pb = 82.

**AuDIT technology** – Thermo Scientific Au/gold Detection & Identification Technology (AuDIT) is a proprietary plating detection technology developed for, and only available on, Thermo Scientific portable XRF analysers, including the Thermo Scientific Niton XL2 precious metal analyser. Several independent, complementary methods in the software work in tandem to alert users to the probability that an item is plated. The primary, patent-pending technology based on elemental XRF signatures works regardless of the gold concentration of the plated surface layer. This technology works for vermeil (gold-plated silver), as well as gold-plated copper, steel, tungsten and any other non-gold substrate.

**Backscatter** – When x-rays interact with low density materials (e.g., polyethylene) they can be scattered back toward the instrument and the operator.

**Brominated flame retardant (BFR)** – Bromine is commonly introduced into a product as a brominated flame retardant, which became a concern in the early 1990s when the connection was drawn between BFRs and the halogenated dioxins and furans. Some forms of BFRs, namely polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs), have already been banned under RoHS regulations.

**CCD camera** – Colour charge-coupled device (CCD) camera and sampling imaging System (integrated as standard into Niton FXL and Niton XL3t GOLDD; optional, Niton XL3t) helps visually identify, locate, specify, and save the image of the analysis area together with elemental analysis results.

**Certified reference material (CRM)** – A standard material that has been certified for certain elements with a given range of uncertainty. Typically, analysis has been performed by multiple methods and multiple laboratories.

**Coating** – A thin covering over a substrate, usually to improve the surface properties such as corrosion resistance. Examples of coatings include anodized surfaces, electrochemical plating, chromate and phosphate coatings, as well as paint and enamels.

**Compton Normalization** – An XRF technique that provides the best results for a wide range of environmental testing and some mining applications, particularly when it is necessary to measure sub-percent concentrations of heavy elements in samples composed mainly of light elements. In environmental testing projects, it is often highly desirable to be able to quickly measure low concentration levels of all of the eight Resource Conservation and Recovery Act (RCRA) heavy metals (Ag, As, Ba, Cd, Cr, Hg, Pb, Se) on site and in real time. Using Compton Normalisation, Thermo Scientific Niton XRF analysers can measure concentrations of many heavy metals.

**Digital signal processor (DSP)** – a device that shapes and produces the spectrum in the XRF Instrument.

**Drill core** – A “cylinder” of material taken as a sample form.

**Element** – A pure chemical substance composed of only one type of atom, e.g., iron (Fe), copper (Cu), gold (Au).

**EPA Method 6200** – At its most basic, EPA Method 6200 is a field-screening method for analysis of in situ and ex-situ soil test samples. Our Niton XL3t Series XRF analyser meets the specifications for this industry-standard method.

**Ex situ** – Latin phrase meaning off-site. Often a soil sample is removed from its original location, prepared (dried, ground, sieved, and cupped), and then analysed ex-situ.

**Extend-a-Pole™** – Providing dual, remote trigger activation for ease of use in multiple orientations, the proprietary telescoping extension pole features an instrument cradle that clamps to the Thermo Scientific Niton analyser, an adapter to hold a GPS or PDA, as well as a fixed tripod adapter.

**Filter** – 1. A mechanism built into the instrument that allows modification of the x-ray energy to preferentially enhance the analysis of certain elements in certain matrices 2. A thin support mechanism for sample collection, such as a 37mm air filter.

**Flow accelerated control (FAC)** – A well-known source of problems in nuclear and fossil-fuel power plants. FAC occurs when carbon steel piping and components are degraded in the presence of flowing water or steam water with low-dissolved oxygen. As the water flows against the carbon steel material, the stable surface oxide layer (typically Fe<sub>3</sub>O<sub>4</sub>) is dissolved into the flowing stream – thinning the walls of piping over time and resulting in catastrophic failures due to rupturing.

**Fundamental Parameters (FP)** – For measuring samples of unknown chemical composition in which concentrations of light and heavy elements may vary from ppm to high percent levels, Fundamental Parameters (FP) analysis is used to simultaneously compensate for a wide variety of geometric effects (including small and odd-shaped samples), plus x-ray absorption, and secondary and tertiary fluorescence effects. FP is the preferred analysis tool for mining, precious metals and all metal alloy testing applications. Using this powerful in-factory calibrated instrument, a Thermo Scientific Niton analyser can then measure the full range of element concentrations in a wide variety of samples for years without any additional calibrations or user input of any kind.

**Geometrically Optimized Large Area Drift Detector (GOLDD™)** – Thermo Scientific GOLDD technology delivers improvements in light element detection (Mg, Al, Si, P, and S), overall sensitivity and measurement times – up to 10 times faster than conventional Si-PIN detectors, and up to 3 times more precise than conventional smaller, silicon drift detectors – without helium or vacuum purge.

**Grade control** – The measurement and adjustment of materials to keep the elements of interest within a specific concentration range.

**Halogen** – The generic name for a group of non-metal elements from Group 17 (formerly VII, VIIA) of the periodic table, comprising F, Cl, Br, I, and At. Halogen free – According to IEC 61249-2-21, the accepted definition of halogen free is 900 ppm maximum Cl, 900 ppm maximum Br, or 1,500 ppm maximum total halogens.

**Helium purge** – 1. The process of replacing the air present surrounding the x-ray tube and detector with helium gas to permit the direct analysis of magnesium, aluminium, silicon, phosphorus and low levels of sulphur in a variety of sample types. 2. The method preferred over vacuum purge systems for analysis of magnesium, aluminium, silicon, phosphorus and sulphur resulting from its higher reliability and reduced potential for instrument contamination. 3. The technique employed by handheld Thermo Scientific Niton XL3t GOLDD analysers and the Niton FXL field x-ray lab for enhanced light element analysis in metal alloys, mining, soil samples and consumer goods screening.

**High filter** – The filter used in the instrument to preferentially fluoresce many of the heavy elements [Z = Ag (47)-Ba (56)].

**Inductively coupled plasma (ICP)** – Traditional testing method, which is generally accepted as accurate, but also destructive and time consuming. Ultimately, this makes the method inefficient. Infilling – taking readings at a higher rate to more closely define the elemental composition of an area of interest; an exploration technique.

**In situ** – Latin phrase meaning in place; the XRF instrument may be used directly on a sample without moving or preparing it, e.g., taking a soil reading in-sit.

**Instrument detection limit (IDL)** – The best possible limit of detection, calculated from a “clean” sample, i.e., one with no interferences.

**Light elements** – Elements below atomic #17. The handheld Niton XL3t GOLDD+ and the Niton XL2 GOLDD analysers as well as the Niton FXL field x-ray lab can detect elements as low as Mg (#12) and Al, Si, P, S, Cl, without the use of helium or vacuum purge.

**Light filter** – The preferred filter used in the instrument to fluoresce light elements if  $Z < 17$ .

**Limit of detection (LOD)** – The smallest concentration of an element that can be detected with reasonable certainty. It is generally regarded as indicating whether an element is present or not, and does not imply that a value obtained is accurate. LOD is usually calculated using 3 sigma (3 standard deviations).

**Main filter** – The preferred filter used in the instrument to fluoresce the transition elements, which include groups 3-12 on the periodic table (all of the first row and some of the second row). Please see [www.nitonuk.co.uk/pdf/periodictable.pdf](http://www.nitonuk.co.uk/pdf/periodictable.pdf).

**NDTr (Niton Data Transfer-remote)** – PC-based software for Thermo Scientific Niton analysers that allows users to display results obtained on their instruments in real time on their computer. Permits users to control their instrument from a PC when the instrument is connected to a test stand, as well as conduct simultaneous data logging of measurement data.

**Niton Data Transfer (NDT)** – A suite of powerful PC-based software tools supplied with each Thermo Scientific Niton XRF analyser, providing advanced instrument setup and data management. Commonly used to quickly and easily document measurement results obtained in the field via tabular data or the popular “certificate print” option.

**Non-destructive** – A feature of element testing that leaves samples undamaged after the testing is complete. All Thermo Scientific Niton analysers are non-destructive.

**Optical emission spectroscopy (OES)** – Differentiating from XRF, the excitation energy in OES comes from a spark formed between the sample and an electrode, which causes the electrons in the sample to emit light. OES is superior in the measurement of light elements in metals, such as carbon. Although OES is considered a non-destructive testing method, the spark does leave a small burn on the sample surface.

**Pathfinder elements** – Elements with better geochemical or analytical characteristics than the main metal, e.g., As can be used as a pathfinder in the search for Au.

**Platinum group metals (PGM)** – A group of 6 precious metals (Ru, Rh, Pd, Os, Ir and Pt) all having similar chemical and physical properties.

**Phthalate** – Phthalates are often used to soften plastics such as the normally-rigid polyvinyl chloride plastics (PVC). They are a group of chemical compounds that are mainly used as plasticizers as in plastic fishing lures, nail polish, adhesives, caulk, paint pigments, and some soft toys made of so-called “jelly rubber”.

**Positive material identification (PMI)** – Inspection process by which alloy chemistry and alloy grade is verified; XRF is the standard industry method used.

**Priority pollutants** – Mercury by EPA method 245.1, antimony, arsenic, beryllium (not by XRF), cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, zinc.

**Product Safety Enforcement Forum of Europe (PROSAFE)** – The European Union’s overseer for the safety of consumer products, through one of the joint market surveillance actions between several member states from the European Economic Area, has utilised Thermo Scientific Niton analysers for XRF screening of certain toys.

**Rare earth elements (REE)** – A collection of 17 elements: Sc (21), Y (39), and the lanthanoids La (57) - Lu (71).

**RCRA metals** – Arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver; Thermo Scientific Niton analysers can measure the RCRA metals as well as priority pollutants and U.S. EPA target analytes.

**Residual element analysis** – Residual element concentrations in carbon steel pipe can be a critical indicator of the expected life and performance of finished components in petrochemical applications. Particular elements of interest include Cr, Cu, and Ni, as well as Mo, Sn, V, Sb, As, and Pb. HF alkylation units can be subject to selective corrosion in a unique manner resulting from elevated levels of residual Cr, Cu, and Ni.

**Restriction of Hazardous Substances (RoHS) directive** – Requires that certain electrical and electronic products be free (except for trace impurities) of mercury, cadmium, hexavalent chromium, PBB, PBDE and lead as of 2006-7-1.

**Slag** – The by-product formed by oxidation at the surface of molten metals. In the production of iron and steel, slag's primary purpose is to purify the iron product through removal of oxides while acting as a protective blanket that stabilises melt temperatures and helps prevent re-oxidation. Slag chemistry is controlled closely to maximize furnace efficiency, reduce impurities in the product, and prolong the life of the refractory lining of the furnace. After the refining process, slags can be recovered and used for commercial purposes such as ballasts, road fill, or mixed with cement for structural applications.

**Small spot** – 3 mm focus feature integrated into XL3 analysers for analysis of hard to isolate samples, such as welds, electronic components, buttons, painted areas on toys, and inclusions in rock face and drill core. Normal beam size is 8mm, the 2 beam sizes can be switched between (with an additional option of 1 mm beam on the Niton FXL)

**Standard deviation or sigma** – A measure of the variability within a sample set. The smaller the value, the closer all the results are to one another. It is calculated by taking a data set and first calculating the mean. Then the mean is subtracted from each individual reading and the calculated value is squared (this gets rid of any negative numbers). Next, these calculated values are averaged and the square root is calculated. This square root is sigma, or one standard deviation. It may also be calculated easily in spreadsheets such as Excel, in Excel use "=stdev (highlight cells of interest)".

**Standard reference material (SRM)** – Material or substance whose property values (one or more) are sufficiently homogeneous and well established for use in the calibration, the assessment of a measurement method, or for assigning values to materials.

**Sulfidation** – Corrosion of metals resulting from reaction with sulphur compounds in high temperature environments. Sulfidation corrosion of piping and equipment within the refining industry continues to be a significant cause of leaks leading to equipment replacements, unplanned outages, and incidents associated with large property losses and injuries. Carbon steels with low silicon (< 0.10%) content can corrode at an accelerated rate when exposed to hydrogen-free sulfidation corrosion conditions. [From API-939-C Guidelines, version 5.0, Jan. 2008].

**Superalloy** – High-performance alloys that can tolerate high temperatures; corrosion and oxidation resistant.

**TestAll™ technology** – Unique feature of Thermo Scientific Niton consumer goods analysers. TestAll automatically determines whether lead is present on the surface coating or in the substrate of the sample undergoing testing. It then applies the appropriate analysis mode, helping to eliminate guesswork for faster, more efficient screening and allowing non-technical users to easily perform measurements with minimal training.

**Tin whiskers** – The main danger posed by the presence of high-purity tin or lead-free tin solder is its tendency to produce filamentary corrosion – more commonly known as "whiskering." Whiskering is a naturally occurring phenomenon that results in the spontaneous and unexplainable growth of tiny, needle-like protrusions. In turn, they break loose, short circuiting system boards and terminals, seriously crippling or destroying entire systems, especially those involved in reliability critical applications such as aircraft, spacecraft, military weapons systems, and electronic medical devices.

**Trace element** – Element present in a sample very small quantities (usually less than 100 ppm).

**Tramp element** – Element found in minute quantities in metal, which can adversely affect some properties of the metal.

**True value** – The actual or certified value of a sample.

**Vacuum purge** – 1. The process of evacuating the air present surrounding the x-ray tube and detector to permit the direct analysis of magnesium, aluminium, and silicon in metal alloys. 2. An inferior method for light element analysis, as compared to helium purge, because of its reduced reliability and higher potential for instrument contamination.

**Waste Electrical and Electronic Equipment (WEEE)** – EU directive 2002/96/EC setting recycling and recovery rates for electrical goods to reduce toxic e-waste.

**X-ray fluorescence (XRF)** – 1. The emission of x-rays from a substance during exposure to an external source of x-rays. 2. The process by which a non-destructive test for material composition is performed. 3. The technique, perfected by the then Niton Corporation in the 1990s and revolutionised at the turn of this century, whereby users are offered a choice of instrument platforms, excitation energies, calibration models, and modes of operation, virtually guaranteeing at least one configuration optimised for their application.



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