thermo scientific

A practical guide to improving cement manufacturing processes and production

ThermoFisher SCIENTIFIC

Table of contents

Overview

Energy & emissions

Technology

Equipment

Request quote or info ›

Request quote or info ›

Overview

What is cement

Cement is a fine, soft, powdery-type substance made from a combination of calcium, silicon, aluminum, iron and other materials, including limestone, shells, gypsum, clay, blast furnace slag (known as fly ash), silica sand, and iron ore.

Cement composition is based on customers' requests, each requiring a different elemental chemistry in recipe. Portland cement, the most common type of cement, is formulated in a variety of strengths and colors, depending on its intended use. Portland cement is used primarily to make concrete, mortar, and grout.

Types of Portland Cement

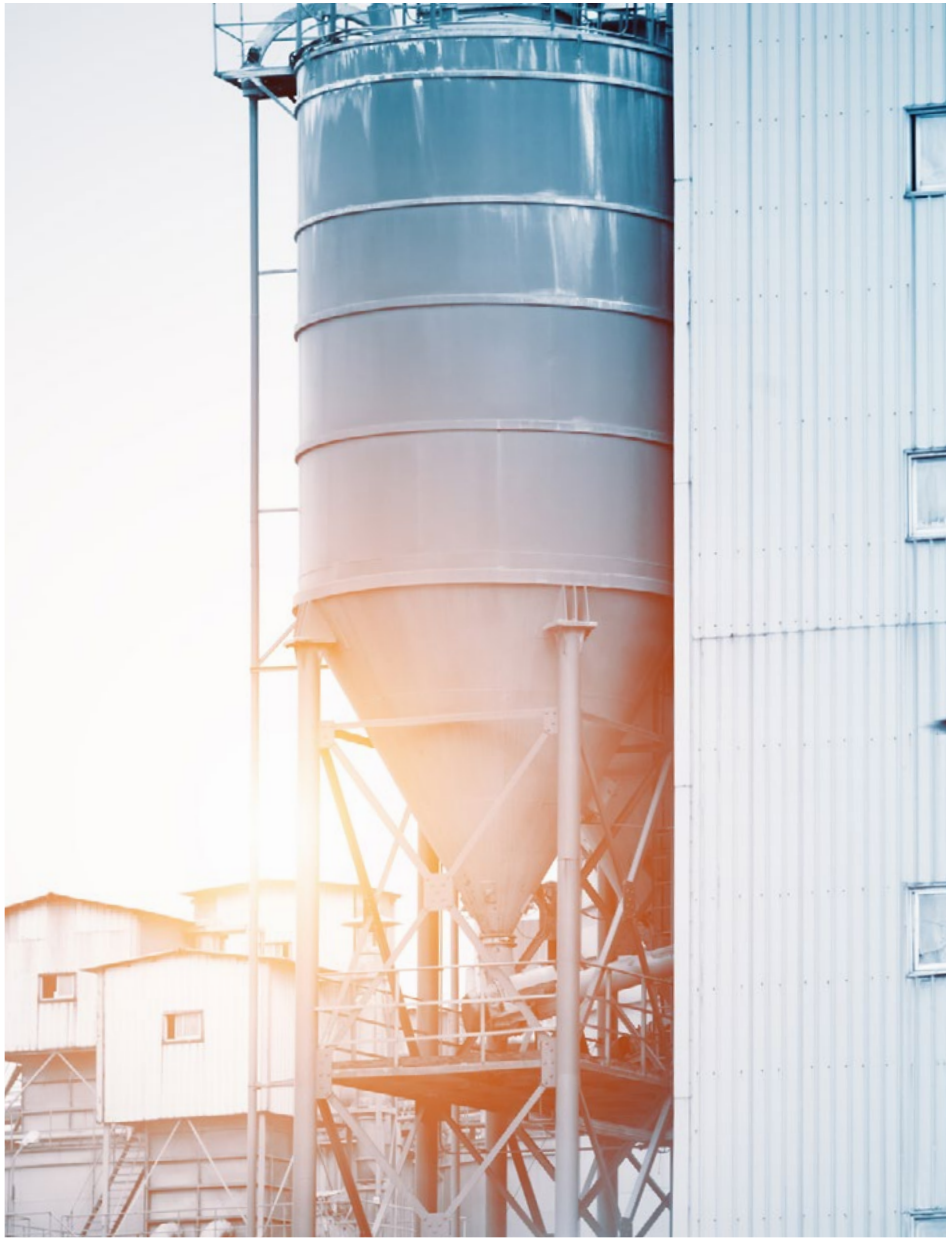
- **Type I** - For use when the special properties specified for any other type are not required.
- **Type IA** - Air-entraining cement for the same uses as Type I, where air-entrainment is desired.
- **Type II** - For general use, more especially when moderate sulfate resistance is desired.
- **Type IIA** - Air-entraining cement for the same uses as Type II, where air-entrainment is desired.
- **Type II(MH)** - For general use, more especially when moderate heat of hydration and moderate sulfate resistance are desired.
- **Type II(MH)A** - Air-entraining cement for the same uses as Type II(MH), where air-entrainment is desired.
- **Type III** - For use when high early strength is desired.
- **Type IIIA** - Air-entraining cement for the same use as Type III, where air-entrainment is desired.
- **Type IV** - For use when a low heat of hydration is desired.
- **Type V** - For use when high sulfate resistance is desired.

NOTE: Concrete is made up of three basic components: water, aggregate (rock, sand, or gravel) and Portland cement, and is used in construction.

The cement production process

There are 4 stages of cement production that help maintain consistent raw material quality with minimal chemistry deviation, from quarry to silo to customer.

1. The Quarry: The cement production process begins with the extraction of limestone and clay from the quarry.
2. Crusher and Pre-Blending: The material is then crushed to reduce particle sizes and blended to reduce variability in composition.
3. Raw Mill and Kiln: Raw materials and additives are blended into the correct ‘recipe,’ then dried, ground, and heated into clinker.
4. Clinker Analysis: The cooled clinker elemental composition is determined, then ground into fine particles.



Request quote or info ›

The quarry

Mining, measuring, and analyzing

The key elemental components for cement are calcium, aluminium, iron and silicon. However, sometimes unwanted elements such as magnesium oxide, and alkalis such as sodium, potassium, and sulfur, exist within the limestone, clay and sandstone that are adverse to the process and reduce the mineability of the quarry. In these cases, online elemental analyzers using prompt gamma neutron activation analysis (PGNAA) technology allow the end user to monitor MgO levels in the limestone and adjust accordingly.

Belt scales help to measure the amount of material that is being mined, and tramp metal detectors can help find any unwanted metals in the raw material, which is extremely important for safety and the protection of the conveyor belt. In addition, handheld XRF analyzers can quickly measure areas in the quarry and any samples that may be taken.

Tips for Improvement

1. Online elemental analyzers allow monitoring of MgO levels in the limestone so timely adjustments can be made.
2. Belt scales help to measure the amount of material that is being mined.
3. Tramp metal detectors can help find any unwanted ferrous and non-ferrous metal contaminants.
4. Handheld XRF analyzers can quickly measure samples.

Crusher and pre-blending

Crushing, blending, and moving

After the material is extracted from the earth, it is crushed to reduce the particle sizes. The materials are stocked into a special pile and blended to reduce the variability in cement composition. The proportions of this raw material blend are dependent upon the elemental composition of the limestone and raw materials that are available within the quarry. The material is then reclaimed from a rake, then fed onto a conveyor that transports the material to another control point called the raw mix proportioning area.

Tips for Improvement

1. Cross-belt online elemental analysis systems can help control stockpile chemistry to meet quality targets.
2. Place an online analyzer after the primary crusher but before the pre-blending stockpile to control the raw material quality within a pre-blending stockpile.

Request quote or info ›

Learn more, read our blog post: **Can Stockpile Chemistry Be Controlled to Meet Cement Quality Targets if There Are Chemistry Variations Across an Entire Quarry?**

Raw mill & kiln

Adding, feeding, and heating

Additives (like sand and iron ore), along with the limestone and clay, are fed from bins to the raw mill. An extremely important step in the cement process is to proportionally feed these materials to the raw mill to ensure the correct “blend” of these materials.

The raw materials, now known as kiln feed, enter a raw mill that consists of a drying chamber and a grinding chamber.

The kiln feed is then fed into a rotary kiln, a large chemical reaction chamber with temperature reaching approximately 1400 degrees C. This forms the clinker (dark grey nodular material) components C3A, C4AF, C2S, and C3S.

Tips for Improvement

1. Belt scale systems proportionally feed materials to the raw mill to ensure the correct “blend”.
2. Conveyor protection switches help prevent accidents and protect equipment.
3. Place an online analyzer at the raw mix proportioning stage to help adjust raw material feed proportions.

Request quote or info ›

Click here to download our application note: **Analysis of Cement Related Materials.**

Clinker

Grinding, cooling, and verifying

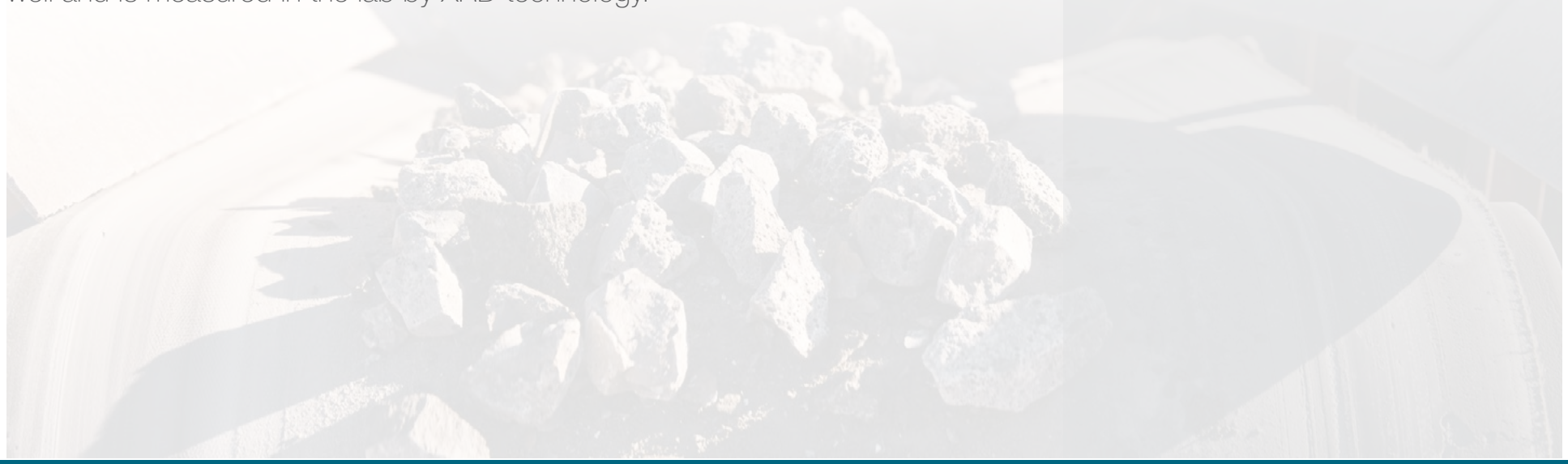
The concentration of each of element in the clinker plays an important role in the physical characteristics of cement such as color and strength.

The determination of the elemental composition of the material can be achieved using XRF analyzers, while the phases are identified using the XRD platform.

The final stage is to grind the cooled clinker into a fine particle and add gypsum to control the setting time of the cement. Mineralogy is important at this stage as well and is measured in the lab by XRD technology.

Tips for Improvement

1. Technology that combines X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) helps ensure consistent clinker quality with both chemical and phase analysis in one simple operation.



Learn more about this process, download the application notes: **Analysis of Clinker Phases with the ARL 9900 Total Cement Analyzer** and **Analysis of Various Oxide Materials with ARL OPTIM'X WDXRF Spectrometer.**

Request quote or info ›

Energy & emissions

Furnace efficiency and energy consumption

Kiln feed material with high chemistry variations requires more fuel in the kiln to properly react and more energy at the finish mill to grind over-reacted clinker. By using an online analyzer to minimize chemistry variation, fuel and energy consumption can be reduced and process upset conditions avoided.

The heat source to run the very hot kilns can be either coal, natural gas, and/or biofuels. Coal is still used in approximately 90% of cement plants globally to deliver the energy needed for the heat inside the kiln. Online coal analyzers using PGNAA technology are used to control the coal blend to a specific heating value in addition to the ash value of the coal as this adds raw materials to the process as well. This allows cement producers to “mix” low cost coals with higher costs coals to provide additional cost savings in fuel and to allow a consistent feed to the kiln.

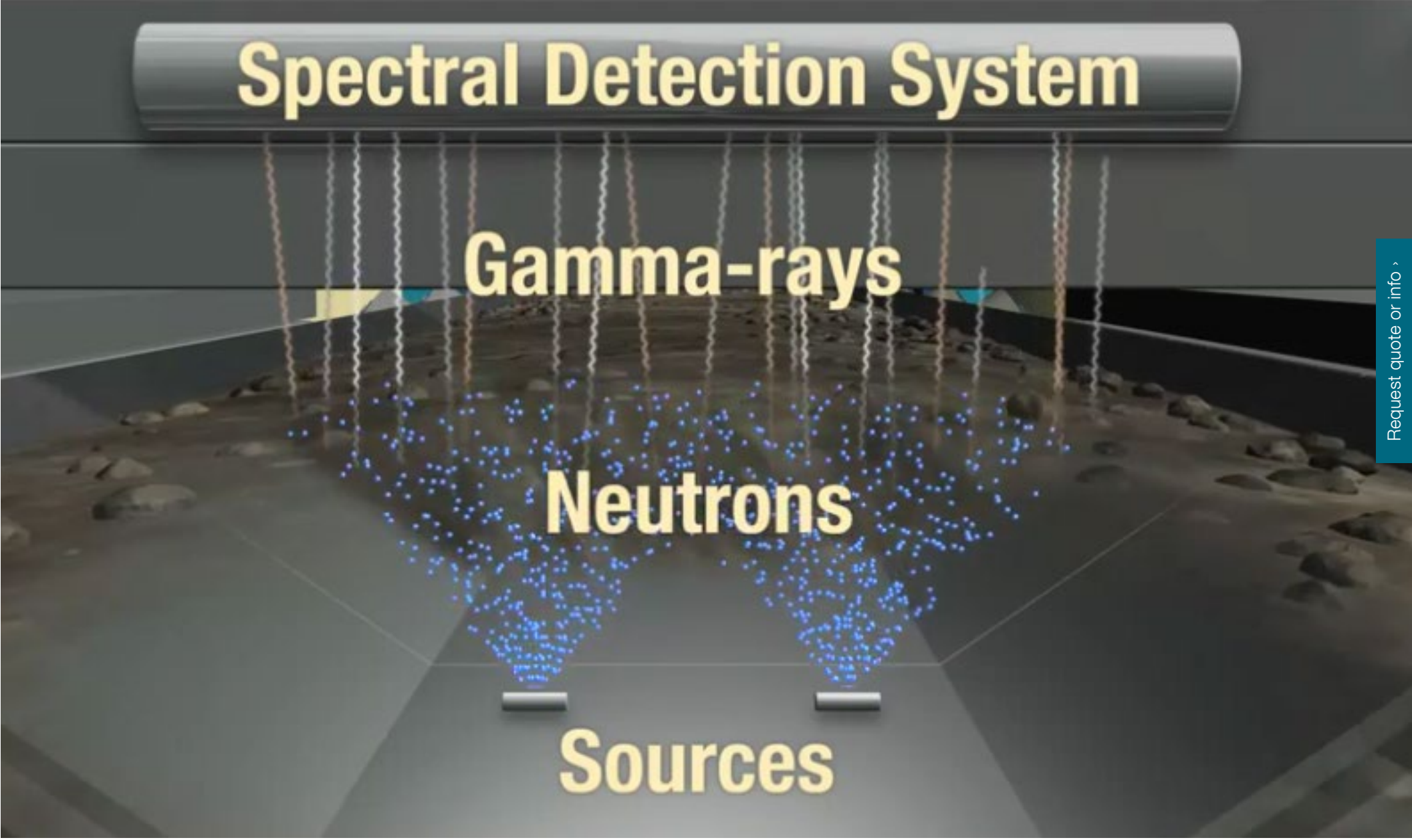
Regulatory compliance

Cement manufacturing is the source of 5% of global CO_2 emissions. 60% of emissions are due to the transformation of raw materials at high temperatures and 40% results from the combustion required to heat the cement kilns 1400°C to1500°C. Therefore emissions monitoring is extremely critical for cement plants to meet regulatory requirements. There are even provinces in China that are only allowing cement plants to operate 9 months out of the year to curb some of the unwanted emissions.

Continuous Emissions monitoring systems are critical for cement plants to monitor harmful emissions such as carbon dioxide, nitrogen dioxide, sulfur and mercury as well as other particulate matters.

Click here to download the application note: **Mercury Monitoring in a Cement Kiln.**

Request quote or info ›



Technology

Technology in action

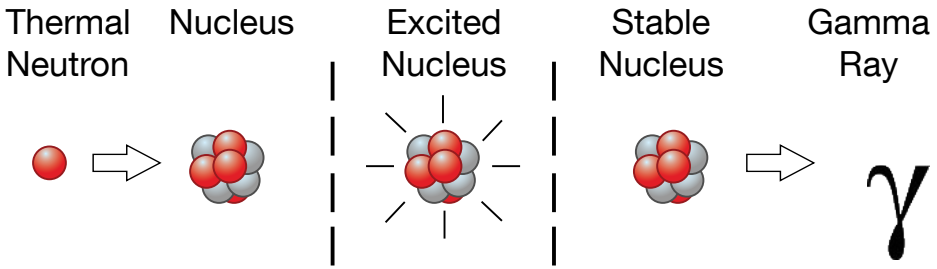
Click below to watch how technology for continuous online analysis of raw materials is used for making cement.

Request quote or info ›

PGNAA and PFTNA technology

Prompt gamma neutron activation analysis (PGNAA) and pulsed fast thermal neutron activation (PFTNA) are non-contact, non-destructive analytical techniques used in online analysis systems to determine the elemental composition of bulk raw materials. Both of these techniques are known collectively as neutron activation analysis and function by bombarding materials with neutrons.

Prompt gamma neutron activation analysis and pulsed fast thermal neutron activation are based on a subatomic reaction between a low energy neutron and the nucleus of an atom. When a thermal, or rather low energy neutron (<0.025 eV) approaches near enough to, or collides with, a nucleus of an atom, an interaction between the neutron and the nucleus takes place. Energy from the neutron is transferred to the nucleus and temporarily elevates it to an excited energy state. The energy is then released, nearly instantaneously, in the form of a gamma ray. The gamma-ray given off has a distinct energy associated with the atom from which it was released. In essence the gamma-ray emitted is like a "fingerprint" of the element. The emitted gamma-rays are detected and an energy spectrum generated which can then be analyzed for elemental composition.



Click here to learn more about about PGNAA and PFTNA technology.

Request quote or info ›

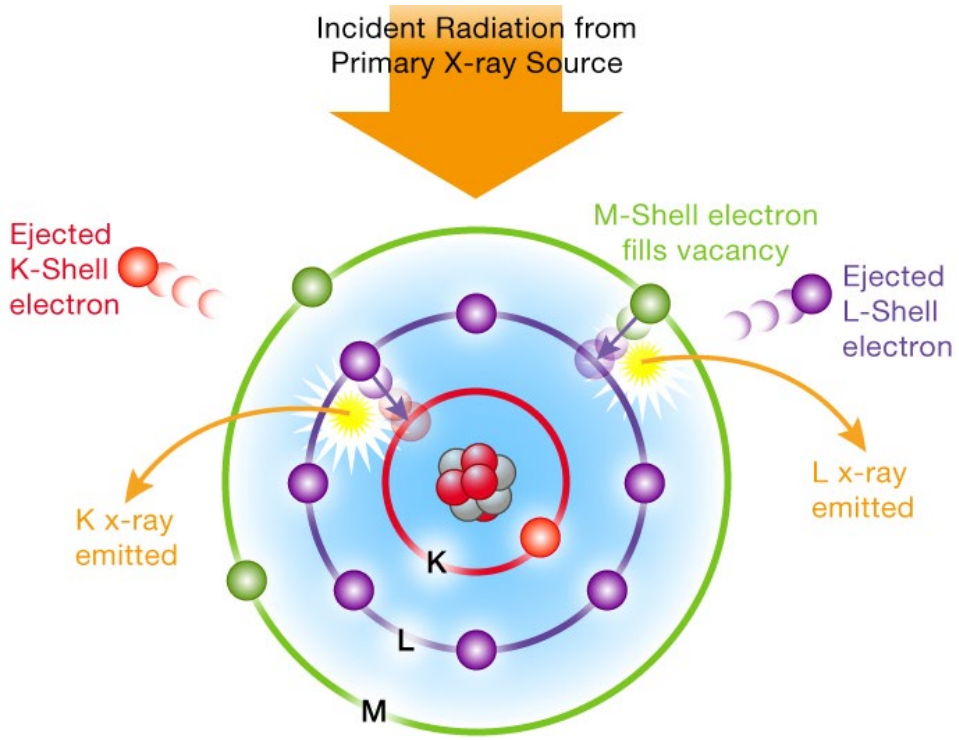
X-ray fluorescence (XRF)

XRF (X-ray fluorescence) is a non-destructive analytical technique used to determine the elemental composition of materials. XRF analyzers determine the chemistry of a sample by measuring the fluorescent (or secondary) X-ray emitted from a sample when it is excited by a primary X-ray source. Each of the elements present in a sample produces a set of characteristic fluorescent X-rays ("a fingerprint") that is unique for that specific element, which is why XRF spectroscopy is an excellent technology for qualitative and quantitative analysis of material composition.

X-ray fluorescence (XRF)

The X-ray fluorescence process

- A solid or a liquid sample is irradiated with high energy X-rays from a controlled X-ray tube.
- When an atom in the sample is struck with an X-ray of sufficient energy (greater than the atom's K or L shell binding energy), an electron from one of the atom's inner orbital shells is dislodged.
- The atom regains stability, filling the vacancy left in the inner orbital shell with an electron from one of the atom's higher energy orbital shells.
- The electron drops to the lower energy state by releasing a fluorescent X-ray. The energy of this X-ray is equal to the specific difference in energy between two quantum states of the electron. The measurement of this energy is the basis of XRF analysis.



Learn more about **XRF Technology** and **WDXRF Technology.**

Request quote or info ›

Request quote or info ›

Equipment

Cement manufacturing processing

Monitoring raw materials in cement manufacturing

CB Omni Agile online elemental analyzer

The CB Omni Agile offers not only enhanced configurability through its modern modular industrial design to suit your application, but a lighter, easier to install analyzer, with the same industry leading performance that you have come to expect.

Product details ›

Ramsey conveyor belt scale systems

Ramsey belt scale systems monitor raw material feed to crushers, mills, screens, preparation plants, and coal-fired power plants to help ensure precise feeding of process materials and maintain product quality.

Product details ›

Ramsey weighbelt feeders

Weighbelt Feeders help provide a consistent feed of raw materials to maintain their desired proportions in the raw mix, which helps reduce material waste and help maintain blend consistency.

Product details ›

Ramsey Oretronic IV tramp metal detector

Tramp metal detectors protect expensive crushers, conveyors and other process equipment from damage by tramp metal.

Product details ›

Niton handheld XRF analyzers

XRF analyzers can provide on-the-spot elemental analysis of quarry samples. They can also determine whether the refractory anchors are of the required grade of steel. Analysis can be carried out at the time of material receipt to reduce the chance of material mismatches during procurement.

Product details ›

Request quote or info ›

Monitoring raw materials in cement manufacturing

Conveyor safety switches and monitors

Conveyor protection switches for bulk material handling equipment are important tools in helping to prevent accidents and protect equipment.

Learn more ›

Level measurement devices, instruments, and sensors

Eliminate failure and maintenance issues with your inventory monitoring and process control system with the Ramsey C-Level continuous level indicator. Ideally suited for bulk solids or liquids, the Ramsey C-Level continuous level Indicator monitors inventory and process control during load-out or filling.

Learn more ›

Radiation detection and monitoring instruments

Radiation detection pagers are used to assess the possible radiation exposure from online elemental analyzers that utilize a neutron source and ensure that these stay within acceptable limits.

Learn more ›

Click here to watch the video on our SPRD personal radiation detector.

Request quote or info ›

Cement bulk material control and handling equipment

CB Omni Agile online elemental analyzer

The CB Omni Agile offers not only enhanced configurability through its modern modular industrial design to suit your application, but a lighter, easier to install analyzer, with the same industry leading performance that you have come to expect.

Product details ›

ARL OPTIM'X cement analyzer

The ARL OPTIM'X analyzer analyzes major and minor oxides in cement and raw materials such as limestone, sand, bauxite, ceramics, refractories, slags and sinter.

Product details ›

ARL 9900 total cement analyzer

The ARL 9900 total cement analyzer ensures consistent clinker quality with both chemical and phase analysis in one simple operation.

Product details ›

Ramsey conveyor belt scale systems

Ramsey belt scale systems monitor raw material feed to crushers, mills, screens, preparation plants, and coal-fired power plants to help ensure precise feeding of process materials and maintain product quality.

Product details ›

AccuLINK software package and RAMOS raw mix optimization software

Software packages link products and processes together to ensure optimal operational efficiency and help meet quality control targets.

Product details ›

Request quote or info ›

Elemental and phase analysis of clinker and cement

ARL 9900 total cement analyzer

The ARL 9900 total cement analyzer ensures consistent clinker quality with both chemical and phase analysis in one simple operation.

Product details ›

ARL EQUINOX 1000 x-ray diffractometer

X-ray diffractometer technology (XRD) is designed to meet structural and phase analysis requirements in both industrial and research laboratories to help ensure consistent clinker quality.

Product details ›

ARL EQUINOX 3000 x-ray diffractometer

This research-grade diffraction system helps obtain quantitative analysis of clinker phases.

Product details ›

Click here to watch the video on benchtop x-ray diffraction system for fast, dynamic analysis.

Request quote or info ›

Coal blending for coal power generation

ECA-3 elemental crossbelt analyzer

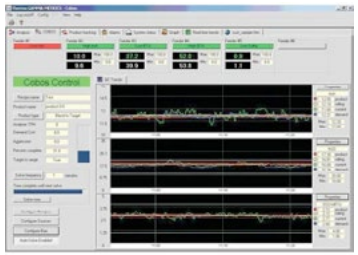
The crossbelt analyzers helps facilitate sorting, blending and out-of seam dilution control, and analyze the composition of the total burden of coal on the belt in real-time.

Product details ›

CQM FLEX coal analyzer

Coal analyzers help minimize variations in coal quality, ensure contract compliance, and improve efficiency.

Product details ›



COBOS coal blend optimization system

This software continuously monitors coal quality for high quality coal blends while achieving more cost-effective, efficient operations.

Product details ›

Ramsey Oretronic IV tramp metal detector

Tramp metal detectors protect expensive crushers, conveyors and other process equipment from damage by tramp metal.

Product details ›

Ramsey conveyor belt scale systems

Ramsey belt scale systems monitor raw material feed to crushers, mills, screens, preparation plants, and coal-fired power plants to help ensure precise feeding of process materials and maintain product quality.

Product details ›

Request quote or info ›

Cement emissions monitoring equipment

Continuous emissions monitoring systems (CEMS)

CEMS are designed to monitor for potentially harmful contaminants and help meet US EPA 40CFR Parts 60 and 75 standards while providing unsurpassed sensitivity, accuracy and reliability.

Product details ›

iQ Series gas analyzers

Gas analyzers help ensure a safe and healthy working environment for personnel in cement plants.

Product details ›

ARL EQUINOX 3000 x-ray diffractometer

This research-grade diffraction system helps obtain quantitative analysis of clinker phases.

Product details ›

Click here to watch the video on our iQ Series gas analyzers.

Request quote or info ›

Frequently asked questions

Q: Where should I place an online analyzer to help ensure consistent raw material quality?

Q: How quickly can my material be analyzed?

Q: How can analysis during cement production help lengthen the life of the quarry?

Q: Can an online analyzer help reduce energy consumption of the cement plant?

Q: Can online analysis reduce process variability using control moduli such as LSF, SM and AM?

Q: Can stockpile chemistry be controlled to meet quality targets?

Q: Can raw mix proportioning be controlled to meet quality targets?

Q: How many materials can be controlled by cross-belt online analysis systems?

Q: What technology is used to analyze the raw material stream used in cement?

Q: What is the difference between PGNAA & PFTNA?

Q: What is a neutron?

Q: How are neutrons supplied for the analysis technique or rather where do the neutrons come from?

Q: Is PGNAA and PFTNA technology safe?

Q: How is the data from online analyzers made available to plant personnel?

Request quote or info ›

Click here to view all the frequently asked questions and answers about online material analysis for cement production.

thermoscientific

Share this eBook

About Thermo Fisher Scientific

Thermo Fisher Scientific is the world leader in serving science. Our mission is to enable our customers to make the world healthier, cleaner and safer. We help our customers accelerate life sciences research, solve complex analytical challenges, improve patient diagnostics, deliver medicines to market and increase laboratory productivity. Through our premier brands – Thermo Scientific, Applied Biosystems, Invitrogen, Fisher Scientific and Unity Lab Services – we offer an unmatched combination of innovative technologies, purchasing convenience and comprehensive services.

For additional information or to request a quote, please click below.

Request quote or info

thermofisher.com/cement

ThermoFisher SCIENTIFIC