A practical guide to improving coal-fired power generation operations

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There are an estimated 2,425 coal-fired power stations in the world, with 280 operating in the US.

Source: <u>Global Energy Monitor</u>

Overview

Where are the coal-fired power plants?

(Top 20) Number of Coal-fired Power Stations by Country in 2020

Country	Construction	Operating
China	105	1,069
India	31	294
United States	0	280
Russia	1	85
Japan	14	82
Indonesia	24	75
Germany	1	74
Poland	4	50
Turkey	2	31
Czech Republic	1	30
Vietnam	8	24
South Korea	4	24
Philippines	5	23
Taiwan	1	22
Ukraine	0	21
Kazakhstan	1	21
South Africa	2	19
Australia	0	19
Spain	0	17
Canada	0	14

(Top 20) Coal Plants by Country in 2020 (MW)

Country	Construction	Operating
China	99,710	1,004,948
United States	0	246,187
India	36,698	228,964
Russia	120	46,862
Japan	9,269	46,682
Germany	1,100	44,470
South Africa	4,770	41,435
South Korea	7,260	37,600
Indonesia	11,840	32,373
Poland	2,470	30,870
Australia	0	24,382
Ukraine	0	22,265
Turkey	1,465	19,514
Vietnam	8,680	18,432
Taiwan	800	18,125
Malaysia	0	13,530
Kazakhstan	636	12,704
Spain	0	9,991
United Kingdom	0	9,718
Philippines	1,558	9,670

Source: endcoal.org

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How coal is used for electricity generation

Every year 1.1 billion tons of coal are burned in the U.S., with 90% of that being used for electricity generation. The interconnected series of steps which takes the coal from the mine to the boiler to deliver reliable electricity to industry and households is aided considerably by various technologies. These steps include measuring tonnages, determining coal quality, ensuring personnel safety, and meeting emission regulations.

Making coal power more efficient

Globally, the coal-fired power plant faces the increasing demands of cost saving, process optimization, and cleaner gas emissions. Here are some areas where operations can be optimized, and environmental concerns can be addressed.

1. Raw material handling

2. Online coal quality analysis

3. PMI and warehouse

4. Continuous emissions monitoring

5. Air quality monitoring

Raw material handling

An enormous amount of raw material, coal in this case, is needed for a power generation plant. The coal must be brought in, pulverized into a powder, fed into a boiler, and then turned into steam.

Raw material handling equipment for each stage of the process includes belt scale systems to move and monitor the weight of goods received, tramp metal detectors to protect the crusher and other expensive equipment, and conveyor protection switches to stop the conveyor if any unexpected accident happens. There are specialty process control instruments to ensure precise feeding of process materials, control inventory, and maintain product quality.
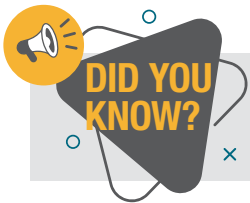
DID YOU KNOW?
A 1000 MWe coal plant uses 9000 tonnes of coal per day, equivalent to an entire train load (90 cars with 100 tonnes in each!).
Source energyeducation.ca

Learn more about **raw material handling equipment**.

Online coal quality analysis

Enhance your operation's profitability when your operators know the coal's quality as it comes from the mine or through the preparation plant. Online elemental coal analyzers and blending software measure the composition of coal in real-time and proactively address process variations to ensure more consistent coal blends.

These analyzers can use either Prompt Gamma Neutron Activation (PGNAA) or Pulsed Fast Thermal Neutron Activation (PFTNA) technology to help provide coal producers with accurate, reliable data to control coal blends and ensure on-spec batches and more efficient use.

Learn more about our **online coal quality analysis products**.

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PMI and warehouse

With handheld XRF and LIBS analyzers, operators can perform positive material identification (PMI) on any piping material in the power plant to help ensure it does not contain incorrect or out of specification metal alloys. In addition, manufacturers who supply the piping can verify the metals and alloys meet customer requirements before they are shipped to the power plant.
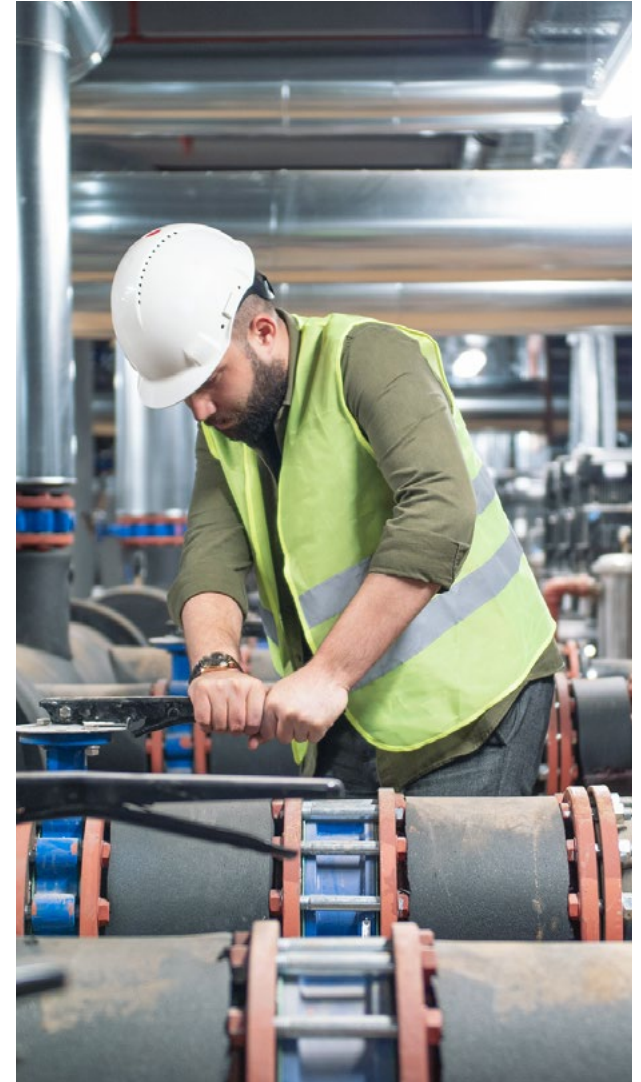
PDF **XRF Technology for the Non-Scientist**
Click here download the free eBook

PDF **LIBS Technology for the Non-Scientist**
Click here download the free eBook

Learn more about our **handheld instruments for PMI.**

Continuous emissions monitoring

The burning of coal releases many pollutants, including sulfur (SOx) and particulate matter. The smokestacks from these power plants also emit greenhouse gases, such as carbon dioxide (CO_2 and methane (CH_4), which are detrimental to the environment and health.
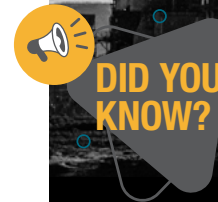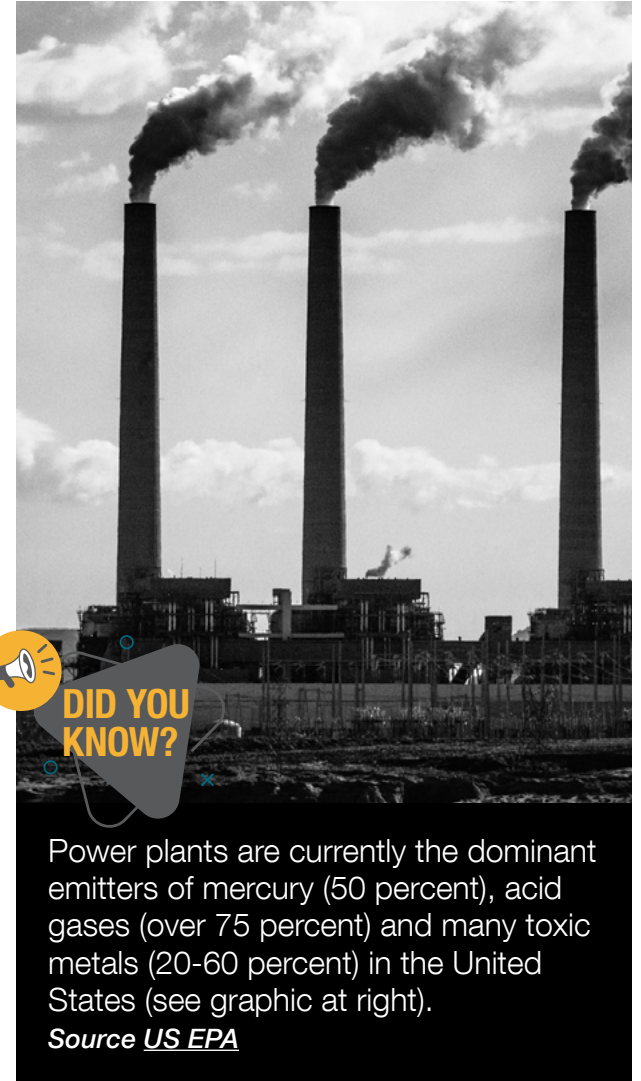
To help alleviate these concerns and adhere to regulatory compliance, power plants utilize technology to reduce the output of these harmful molecules.

There are Continuous Emissions Monitoring Systems (CEMS) which include Particulate Matter (PM) CEMS and Mercury (Hg) CEMS. These probes are installed in stack and transfer gas to PM and Hg analyzers in the shelter, helping coal-fired power plants to comply with local PM and Hg emission regulation and achieve optimal process performance.

DID YOU KNOW?

Power plants are currently the dominant emitters of mercury (50 percent), acid gases (over 75 percent) and many toxic metals (20-60 percent) in the United States (see graphic at right). *Source US EPA*

PDF **Mercury Emissions, Regulations, and Monitoring**
Click here download the free eBook

Learn more about our **continuous emissions monitoring systems**.

Air quality monitoring

Governmental agencies continue to work toward developing regulations that minimize the release of pollutants and harmful toxins in the air by coal-fired power plants. Using proven and reliable technology helps ensure ambient air quality complies with local environmental regulations, allowing all of us to breathe easier.

Air quality monitoring systems can measure air quality, low and high levels of criteria pollutants, as well as other gases and toxins, and helps ensure ambient air quality complies with local environmental regulations (SOx, NOx, CO, Ozone, PM 2.5/ PM10).

Learn more about our **ambient gas monitors**.

Technology in action

See the technology utilized by coal mining operations for minute-by-minute quality analysis of critical coal streams.

Click here to watch the full video ›

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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.

Thermal Neutron   Nucleus   Excited Nucleus   Stable Nucleus   Gamma Ray
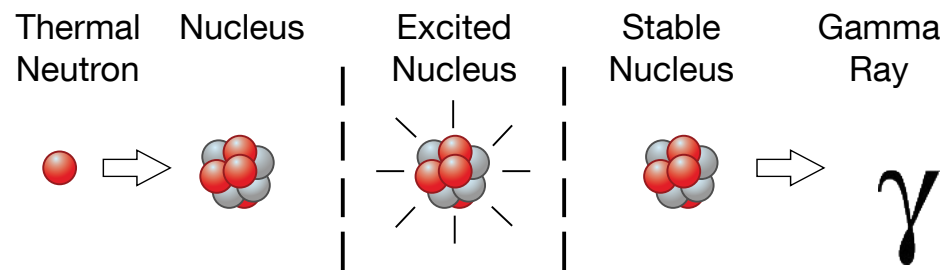
Learn more about **PGNAA** and **PFTNA technology**.

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.

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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.

Incident Radiation from Primary X-ray Source

Ejected K-Shell electron

M-Shell electron fills vacancy

Ejected L-Shell electron

K x-ray emitted

L x-ray emitted

K

L

M
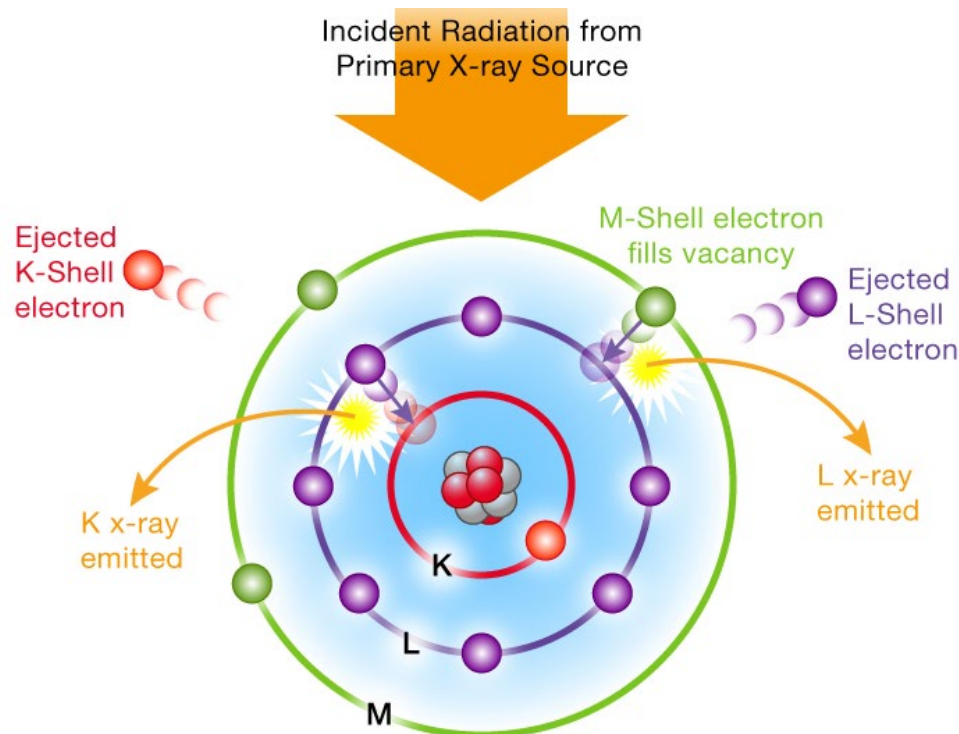
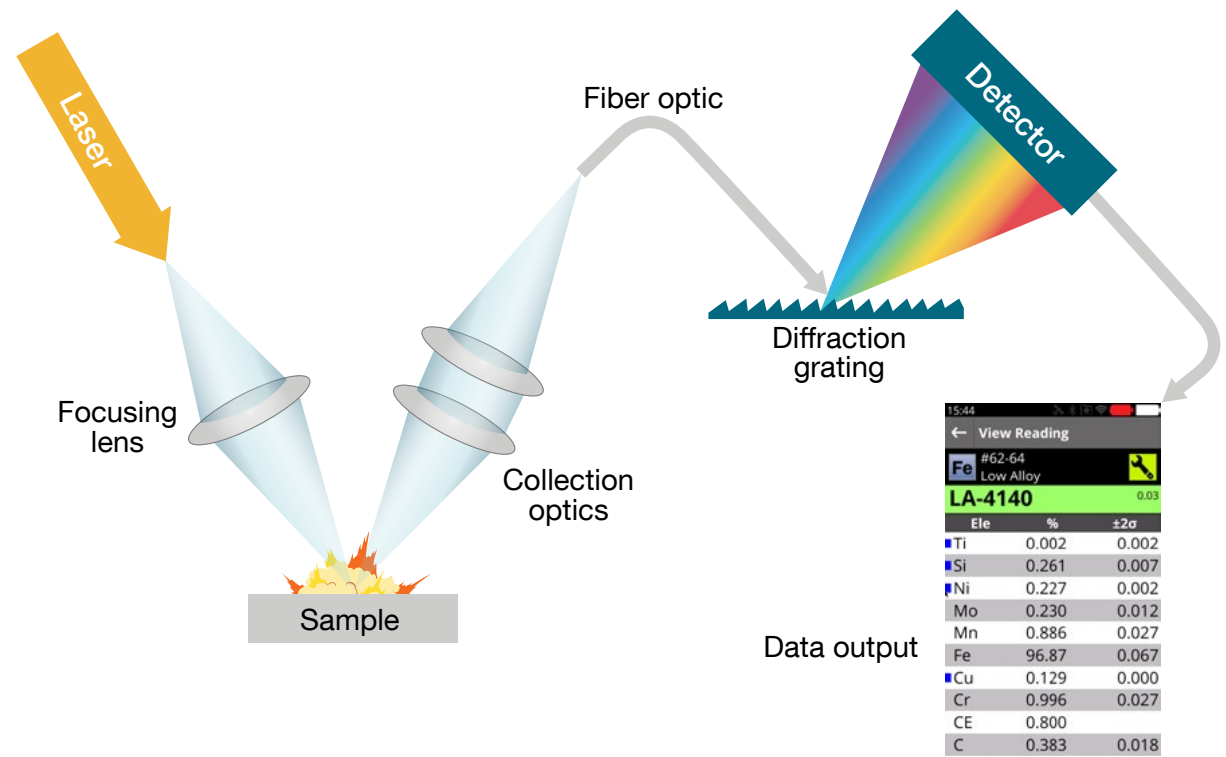Learn more about **XRF technology** and **WDXRF technology.**

The LIBS analysis process

The LIBS technique utilizes a high-focused laser that interacts with the surface of a material and forms a plasma in which the material is broken down into single elements.

1. A laser pulse is produced by the analyzer and pointed at the sample surface.

2. The surface is ablated and enters the plasma. The plasma atomizes the samples, and the excited atoms emit light as they return to ground state.

3. The emitted light is transferred through fiber optics and enters the spectrometer through a slit.

4. The light interacts with a diffraction grating where it is split into single wavelengths/ colors.

5. The single wavelengths/ colors hit the detector and produce spectral data.

6. The central processing unit (CPU) analyzes the spectral data and determines the concentration of each element present in the sample.

7. Composition data and identified alloy grade are displayed and stored via memory for later recall or download to an external PC.

Laser

Focusing lens

Collection optics

Sample

Fiber optic

Detector

Diffraction grating

Data output

View Reading
Fe #62-64
Low Alloy
LA-4140 0.03

Ele	%	±2σ
Ti	0.002	0.002
Si	0.261	0.007
Ni	0.227	0.002
Mo	0.230	0.012
Mn	0.886	0.027
Fe	96.87	0.067
Cu	0.129	0.000
Cr	0.996	0.027
CE	0.800	
C	0.383	0.018

Gas analyzers

Discover more control over your data and your day with the Thermo Scientific iQ Series Gas Analyzers. Watch the video below to learn more.

Engineered to get **smarter over time.**

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Equipment ⚙

Coal-fired power plant workflow

Take an interactive look at our solutions across the coal-fired power plant workflow, from raw material handling to warehouse management.
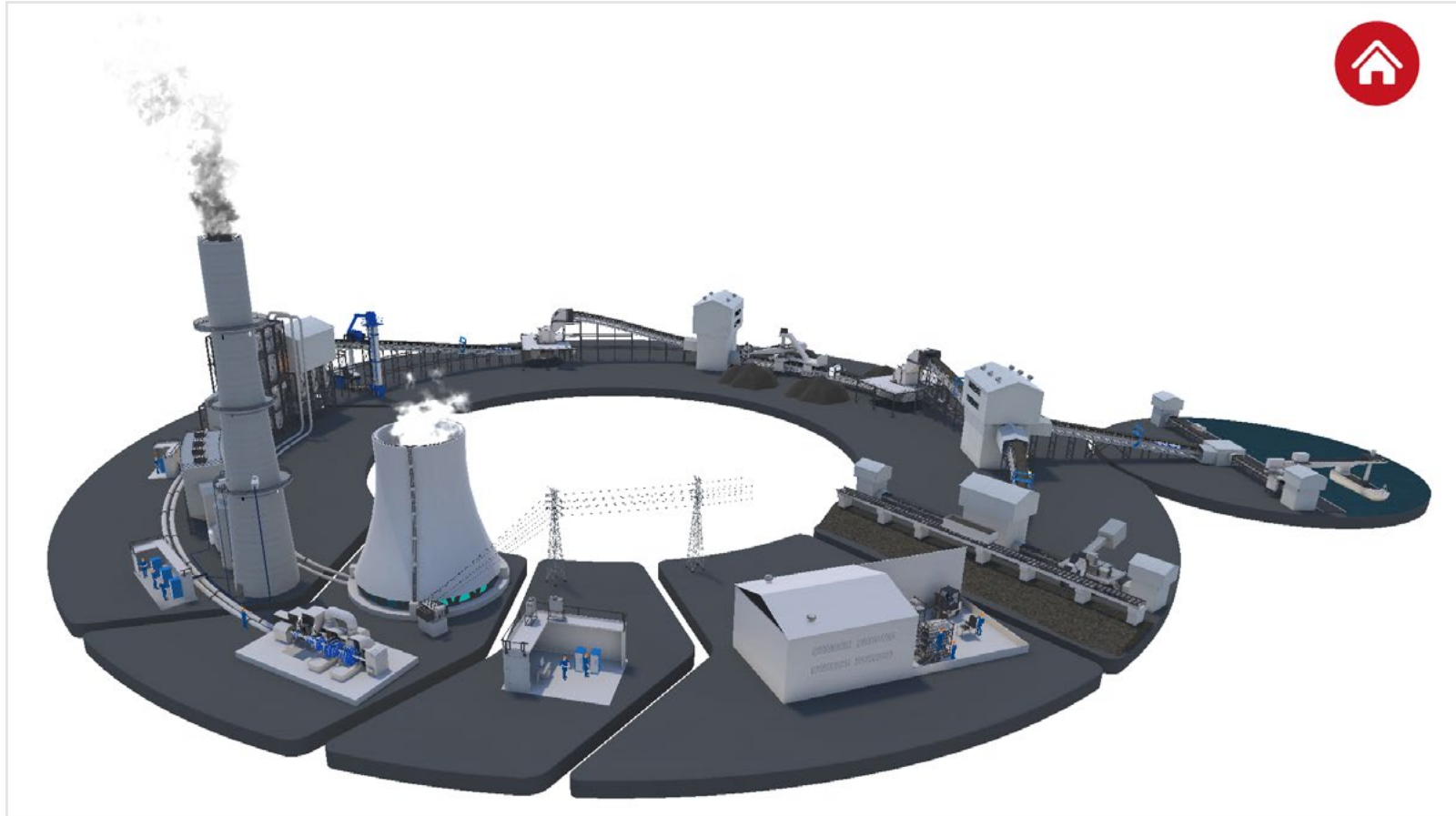
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Coal raw material handling

Thermo Scientific™ Ramsey IDEA Belt Scale System

Get basic rate information and totalization functions in processes involving non-critical or lower-value materials with ±1% accuracy. Ideal for operations where economy and ease of installation are important considerations.

Product details ›

Thermo Scientific™ Ramsey Series 20 Belt Scale System

Monitor your conveyor belt scale feed with an accuracy of ±0.5%, even in the most demanding industrial applications. Designed for general in-plant belt conveyor weighing.

Product details ›

Thermo Scientific™ Ramsey Series 17 Belt Scale System

Run your high-speed plant and process operations with an accuracy of ±0.25% with the Ramsey Series 17 Belt Scale System. Features a multi-idler weighbridge that permits more scale-borne time, minimizing alignment errors.

Product details ›

Thermo Scientific™ Ramsey Series 14 Belt Scale System

Experience high performance for loadout, inventory monitoring, and fee-holder type applications. Designed for basis-of-payment applications requiring certification by government and regulatory agencies.

Product details ›

Thermo Scientific™ Ramsey Micro-Tech 9000 Electronics

This series of electronic integrators, available in field- or panel-mount versions, are suitable for belt conveyor scales, weighbelt feeders, loss-in-weight feeders, impact flow meters, and other dynamic weighing systems.

Product details ›

Thermo Scientific™ Ramsey Oretronic IV Tramp Metal Detector

Prevent damage of expensive downstream equipment from tramp metal on conveyor belts. Can detect all types of metallic scrap, including bucket teeth, manganese steel mantles, bore crowns, bar scrap chains, tools, and more.

Product details ›

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Coal raw material handling

Thermo Scientific™ Ramsey Model 60-12 Speed Sensors

Get reliable and accurate speed-sensing for your belt scale system. Its rugged, cast-aluminum housing makes it suitable for outdoor installations.

Product details ›

Thermo Scientific™ Ramsey Model 60-23P Under Speed Switch

Monitor under speed or slippage. This conveyor safety switch monitors the rotational velocity of conveyor belts, bucket elevators, and other types of rotating equipment.

Product details ›

Thermo Scientific™ Ramsey Belt Misalignment Switch

Identify potentially hazardous situations with bulk handling equipment. Conveyor safety switch monitors the position and tracking of conveyor belts and activates an alarm if the belt skews or misaligns.

Product details ›

Thermo Scientific™ Ramsey Safety Cable Pull Switch

Keep personnel safe and equipment from being damaged with this emergency shutdown device for conveyors or other equipment. Will activate an alarm when force is applied to the pull cable at any position.

Product details ›

Thermo Scientific™ Ramsey Series 60-200 Motion Monitoring Systems

Improve monitoring of underspeed, overspeed, and zero-speed conditions on bulk handling systems.

Product details ›

Coal analysis and coal quality monitoring

Thermo Scientific™ CQM FLEX Coal Analyzer

Minimize variations in coal quality, ensure contract compliance, and improve efficiency. Incorporates either Prompt Gamma Neutron Activation (PGNAA) or Pulsed Fast Thermal Neutron Activation (PFTNA), and it provides the option of sourcing the neutrons from traditional Cf-252 radioactive sources or via an electrically driven neutron generator.

Product details ›

Thermo Scientific™ ECA-3 Elemental Crossbelt Analyzer

Facilitate coal sorting, blending and out-of seam dilution. The ECA-3 is a Prompt Gamma Neutron Activation (PGNAA) coal sampling unit designed to mount around an existing conveyor belt and analyze the composition of the total burden of coal on the belt in real-time.

Product details ›

Thermo Scientific™ COBOS Coal Blend Optimization System

Blend up to six coal sources to meet coal quality analysis specifications at the lowest cost. Controls coal sorting and blending operations with software that continuously monitors coal quality.

Product details ›

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PMI and warehouse

Thermo Scientific™ Niton™ Apollo™ Handheld LIBS Analyzer

Confidently perform elemental analysis with the Apollo handheld LIBS analyzer. When carbon detection and mobility are top of mind, industrial businesses rely on the Apollo LIBS analyzer for superior performance and enhanced productivity.

Product details ›

Thermo Scientific™ Niton™ XL5 Handheld XRF Analyzer

The XL5 handheld XRF analyzer is the lightest, smallest, most powerful portable XRF analyzer available for elemental determination.

Product details ›

Continuous emissions monitoring systems (CEMS)

Thermo Scientific Mercury Freedom System

Measure elemental, ionic and total mercury in exhaust stacks from coal-fired boilers and waste incinerators. Meet or exceed performance specifications outlined in U.S. EPA PS-12A and/or Part 75 provisions for continuous Mercury CEM systems in addition to the latest MATS and MACT rules.

Product details ›

Thermo Scientific Continuous Emissions Monitoring System for Total Reduced Sulfur

Measure total reduced sulfur (TRS) using field-proven, pulsed fluorescence technology with Thermo Scientific Continuous Emissions Monitoring Systems (CEMS).

Product details ›

Air quality monitoring systems

iQ Compliance Monitoring

Measure air quality, low and high levels of criteria pollutants, as well as other gases and toxins. Using proven and reliable technology, our instruments help ensure ambient air quality complies with local environmental regulations (SOx, NOx, CO, Ozone, PM 2.5/PM10).

Learn more ›

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