thermo scientific

A practical guide to improving metal and alloy sorting for scrap metal recyclers

Includes **7 best practices**

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Overview

The importance of accurate alloy analysis

XRF analysis for scrap sorting can help upgrade stock, increase inventory value, and provide a higher quality of product to customers.

Scrap metal recycling has become big business, but globalized trade in scrap metal, alloy stock and finished products has increased the costs of alloy mix-ups for suppliers, distributors and industrial consumers.

The exact chemical composition of scrap, including the existence of contaminants or hazardous elements, must be determined for quality, safety and regulatory compliance.

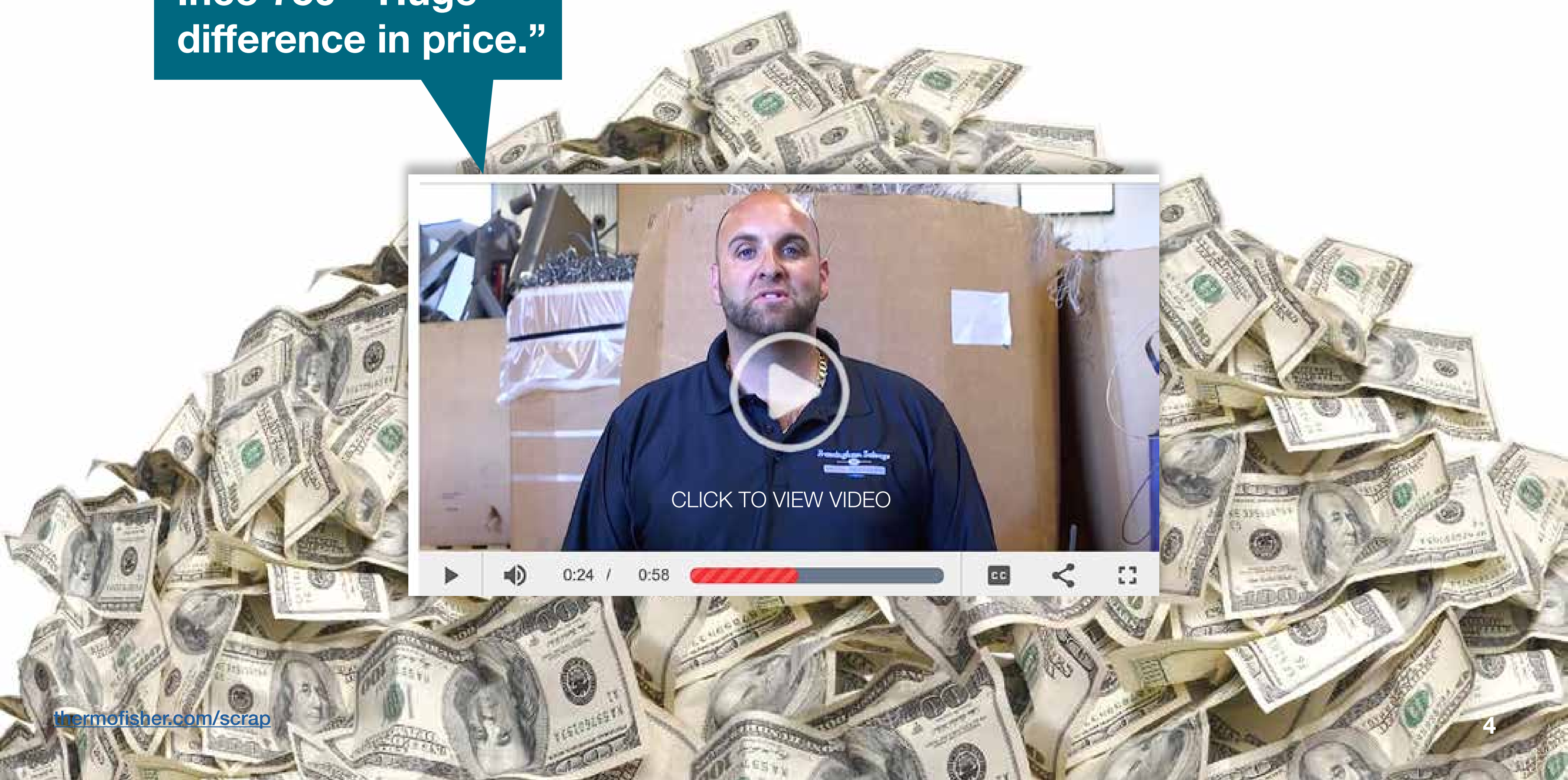
Scrap metal recyclers use handheld XRF to rapidly identify and accurately sort any type of metals and alloys at material transfer points and guarantee the quality of the batch delivered to their customers.

thermofisher.com/scrap

Accurate sorting can bring surprises…. and revenue

"What we thought was 304 Stainless turned out to be Inco 750 – Huge difference in price."

Handheld XRF analyzers can verify elements of interest in virtually all types of metal alloys, from trace levels to commercially pure metals, and are capable of distinguishing alloy grades that are nearly identical in composition to one another.



Know the value of your electronic waste and precious metals

One metric ton of circuit boards can contain 40 to 800 times the amount of gold and 30 to 40 times the amount of copper mined from one metric ton of ore in the US. (source: Materials, EISSN 1996-1944, Published by MDPI)

Rare Earth Elements (REEs) can be found in wastes from mobile phones, televisions, computers, and cameras, as well as high-power magnets, fluorescent lamps, catalytic converters and metal alloys.

Recycling facilities can recover 35,000 pounds of copper, 772 pounds of silver, 75 pounds of gold, and 33 pounds of palladium for every one million cell phones (source: USGS)

Pure gold is usually alloyed with other metals, such as silver, copper, platinum or palladium, to increase its strength before being made into jewelry, decorative items, electronics, dental fillings and coins – which could end up at your recycling facility.

After you sort out your precious metals from the scrap, you will know the gold purity from your analysis, and can calculate the value before sending it to the refiner.

Protecting brand and bottom line

Accurate sorting affects manufacturing finished products

Many varieties of metal, including high temperature alloys, are entering scrap yards, often from unknown sources or with mislabeled or misidentified documentation about the origin and composition. Since manufacturers are increasingly using recycled materials in their fabrication processes, the material integrity of the finished product could be compromised.

Accurate sorting and metal identification is paramount to the safety of the consumer, as well as your ability to satisfy your customer.

> The industry can no longer rely on the 'old ways' of verification by using a grinding wheel to conduct spark tests or chemical tests that also require the storage and handling of hazardous materials. Those tests are simply not as accurate or as reliable as the latest **XRF technology**; and customers will no longer accept shipments that "may or may not meet" their specifications.

"Sorting is very important because we need to guarantee that the material we are shipping to consumers is what we say it is….If it isn't, the mill or foundry we're shipping to could reject the load or downgrade it, and that would hurt our reputation—and our bottom line."

***Recycling Magazine**, quoting the owner of a Massachusetts-based salvage yard*

Scrap recyclers need to supply the aluminum industry with clean scrap to meet regulations

Aluminum from scrap yields an energy and green-house emissions savings of 95%

The production of secondary aluminum allows businesses to comply with environmental regulations, such as REACH and LEED, without any loss of quality. However, the addition of scrap into the aluminum production line is a major challenge for the industry. Compared to the clean, neatly-packaged, and well-defined alumina raw material to which manufacturers are accustomed, post-consumer scrap is composed of a mixture of wrought and casting grades.

With end-product quality, process integrity, safety, and regulatory compliance at risk, accurate knowledge of the grade and composition of the scrap material being introduced into the process is a necessity. To help ensure product integrity, scrap metal operations rely on handheld XRF analyzers for accurate, reliable material identification.

Equipment

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Products

Thermo Scientific™ Niton™ XL5 Plus Handheld XRF Analyzer

Confidently perform elemental analysis, including lightweight elements. Identify pure metals and alloys, and detect tramp elements. Thermo Scientific XL2 100G, XL2 Plus and XL5 handheld XRF analyzers are great technologies to analyze metal scrap.

Product Details >

Thermo Scientific™ Niton™ Apollo™ Handheld LIBS Analyzer

When carbon detection and mobility are needed in addition to standard elemental analysis, scrap metal recyclers use the Niton Apollo for superior performance and enhanced productivity. Identify low alloy/ carbon steels and L and H grade steels.

Product Details >

Thermo Scientific™ASM™ IV Series Automatic Scrap Monitoring System

Radiation detection portals & monitors Detect illicit nuclear materials inside packages or cargo at airports, seaports, borders, government buildings, food storage and handling facilities, transportation stations, couriers and freight companies with radiation monitoring devices.

Product Details >

What to look for in an XRF analyzer

Alloy analyzer expectations of today's recycler

Minimum requirements:

- Accurate, robust chemistries for many thousands of alloys
- Expert concierge support and training
- Fast, high confidence ID's for most common alloys
- Environmentally sealed and hardened for harsh conditions
- Detector protection grids and clip-on engine guard
- Ability to detect and flag tramp elements
- Point-and-shoot ease of use
- Good training and support
- Single piece, light, ergonomic, balanced, handheld unit under 4lbs
- High power, lightweight, Li ion batteries that last for 6+ hours
- Minimum two 4-hour batteries to supply 8-hour operation

Watch this video for evidence of the fast and accurate XRF analysis with the Thermo Scientific™ Niton™ XL2 Plus handheld XRF analyzer.

Radiation measurement and security instruments

The Thermo Scientific™ ASM-IV automatic scrap monitoring system is a configurable platform to prevent radioactive materials from entering scrap metal and metal processing workflow resulting in expensive plant decontamination and shutdown.

Offering unparalleled sensitivity and reliability, the ASM-IV system provides the perfect solution for portal monitoring applications that require the lowest possible alarm thresholds.

- Monitor and prevent workflow contamination
- Prevent expensive costs of radiation cleanup
- Quickly identify orphaned sources
- Remote monitoring of system health to maximize uptime
- Daily scan event tracking and monthly reporting

Upgrade!

Current ASM II/III/SE users can easily upgrade to a new ASM IV Automatic Scrap Monitoring system.

Kits are available and the process is easy. Get all the benefits of the ASM IV system!

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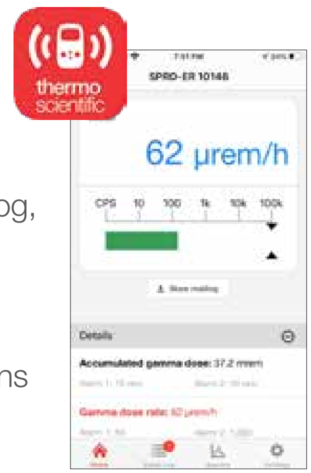
Handheld radiation detection devices

Thermo Scientific™ RadEye™ PRD4

- Spectroscopic personal radiation detector
- RIID Capability in the palm of your hand
- Compact, rugged and reliable
- Worn on belt for constant monitoring
- 150 hours from 2 AAA batteries
- Phone app available with real time indications on multiple connected phones
- Quickly share time indications on a smart phone or tablet

Radeye User App

- Works on IOS and Android phones and tablets
- Requires RadEye Bluetooth battery back
- Simple Interface for most customers looking to capture, log, and send instrument readings to a third-party user.
- Visual and audible alarms
- Email specific files (including spectra files on the SPRDs)
- Integrates with RadResponder and Third Party Applications



RadEye PRD4 kit

Lu test kit adaptor for performance checking, cable and docking stating for detailed analysis of data on a PC.

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Best practices

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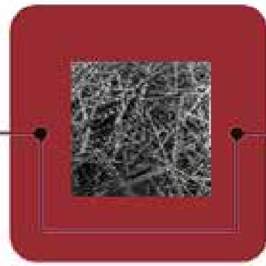
1 Grind it clean

Coatings/ platings

Watch for Ni coated Fe! The XRF may call this pure Ni if coating is not removed!

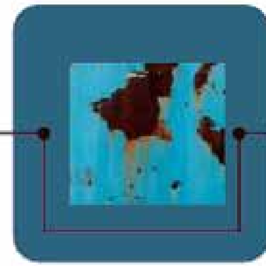
Example: Refinery reaction vessel



Residual paint

Paint will interfere with chemistry – can misidentify alloy

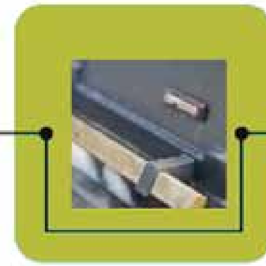
Example: Painted aluminum extrusion window frames – 6063



Corrosion & oxide layer (rust)

Grind it clean to the underlying metal.

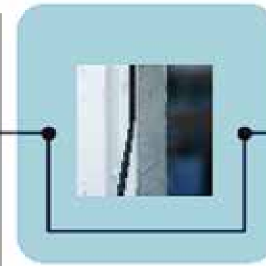
Example: Metals that have been sitting out in the elements



Scale

Surface scale can give errors in chemistry

Example: Cast grill lids – 384, furnace pipes



Interfering materials

Find clean surface or remove interfering materials

Example: Frames stuck with rubber and caulking, tank with sediment

Metallic dust

Dust that covers the surface interferes with the analysis

Example: Welding fumes, grinder residue

2 Take layers of metal apart

Entrapped lead

Analyze each layer separately

Copper-bearing electronics

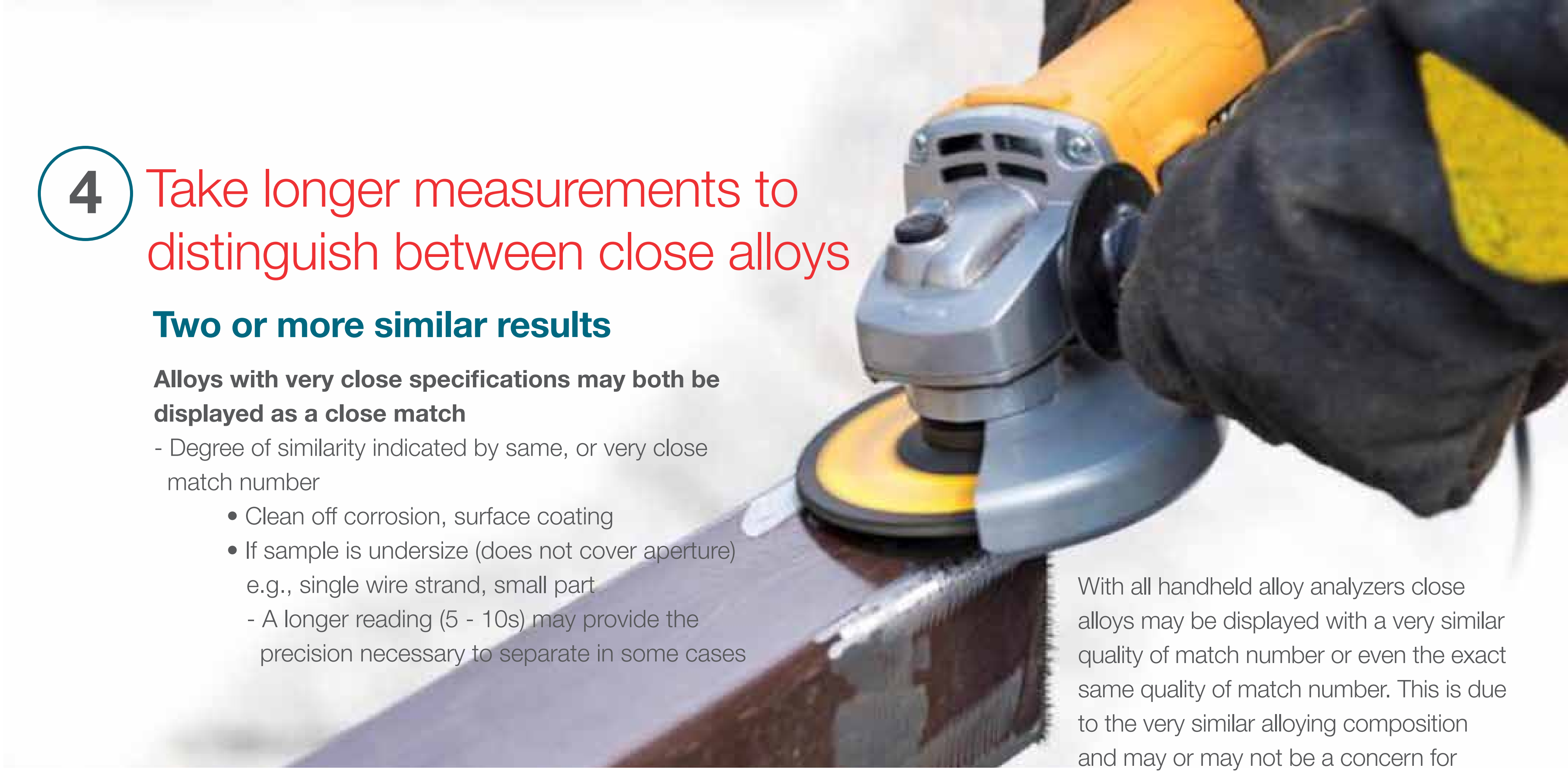
Disassemble first

3 Grind it to a powder

The amounts of recoverable Pt, Pd, and Rh in each catalytic converter can range from 1-2 grams for a small car to 12-15 grams for a big truck in the US. To avoid considerable financial losses, there is a definite advantage in having the ability to determine quickly and accurately the contents of Pt, Pd, and Rh in spent catalytic converters at the collector's site or in the refineries.

TIP for analysis: Pulverize material to a maximum 250µm and load in XRF sample cups or sample bags for analysis.

https://tools.thermofisher.com/content/sfs/brochures/AutoCatalyticConverter-AppNote.pdf



4 Take longer measurements to distinguish between close alloys

Two or more similar results

Alloys with very close specifications may both be displayed as a close match

- Degree of similarity indicated by same, or very close match number
  - Clean off corrosion, surface coating
  - If sample is undersize (does not cover aperture) e.g., single wire strand, small part
    - A longer reading (5 - 10s) may provide the precision necessary to separate in some cases

Trade Name	Ti Min	Ti Max	Cr Min	Cr Max	Fe Min	Fe max	Co Min	Co Max	Mo Min	Mo Max
Hast C4	**0.3**	**0.7**	14	18	0	3	0	2	14	17
Hast S	-	-	14.5	17	0	3	0	2	14	16.5

With all handheld alloy analyzers close alloys may be displayed with a very similar quality of match number or even the exact same quality of match number. This is due to the very similar alloying composition and may or may not be a concern for most facilities that sort into categories, like 18-8 Cr-Ni stainless steel as opposed to a finer sort into 304 vs 321 stainless steel. However, the most stringent sorting requirements may demand that the user attempt to resolve close calls. In such cases cleaning the surface, taking more or longer measurements, obtaining a larger sample (wires, turnings) or sending to a lab may all be strategies that help.

5 Be careful of the fragile XRF window

One source of possible error in use of these analyzers is the extreme range of sizes and shapes that the analyzers have to deal with. Suppliers have gone to great lengths to make these analyzers as robust as possible in dealing with this issue. Examples of difficult shapes are wires, turnings, mesh, screening and powders.

Handheld X-ray fluorescence (HHXRF) has evolved the most robust solutions in this regard, including detector protection grids and clip-on engine guard, although mistakes can still be made if the sources of error are not considered. Small turnings have been one of the most frustrating for many HHXRF users as the sharp edges have broken many fragile XRF windows resulting in costly repair bills. Powders can cling to the measuring window and add to subsequent readings. Even welding fumes can settle out on the window and add false metal concentration readings.

LIBS avoids most of these issues by eliminating the need for a fragile window. LIBS however, cannot measure from any standoff position whereas XRF can test from a few millimeters from the surface of the sample with only some data quality loss.

Sharp Edges	Powders	Fumes
Turnings with sharp edges have broken many fragile XRF windows resulting in costly repair bills.	**Powders can cling to the measuring window and add to subsequent readings.**	**Welding fumes can settle out on the window and add false metal concentration readings.**

6 Take radiation safety training

Radiation

The analyzer emits a directed radiation beam when the tube is energized (tube based instrument) or when the shutter is open (isotope based instrument). Reasonable effort should be made to maintain exposures to radiation as far below dose limits as is practical. This is known as the ALARA (As Low as Reasonably Achievable) principle. For any given source of radiation, three factors will help minimize your radiation exposure:

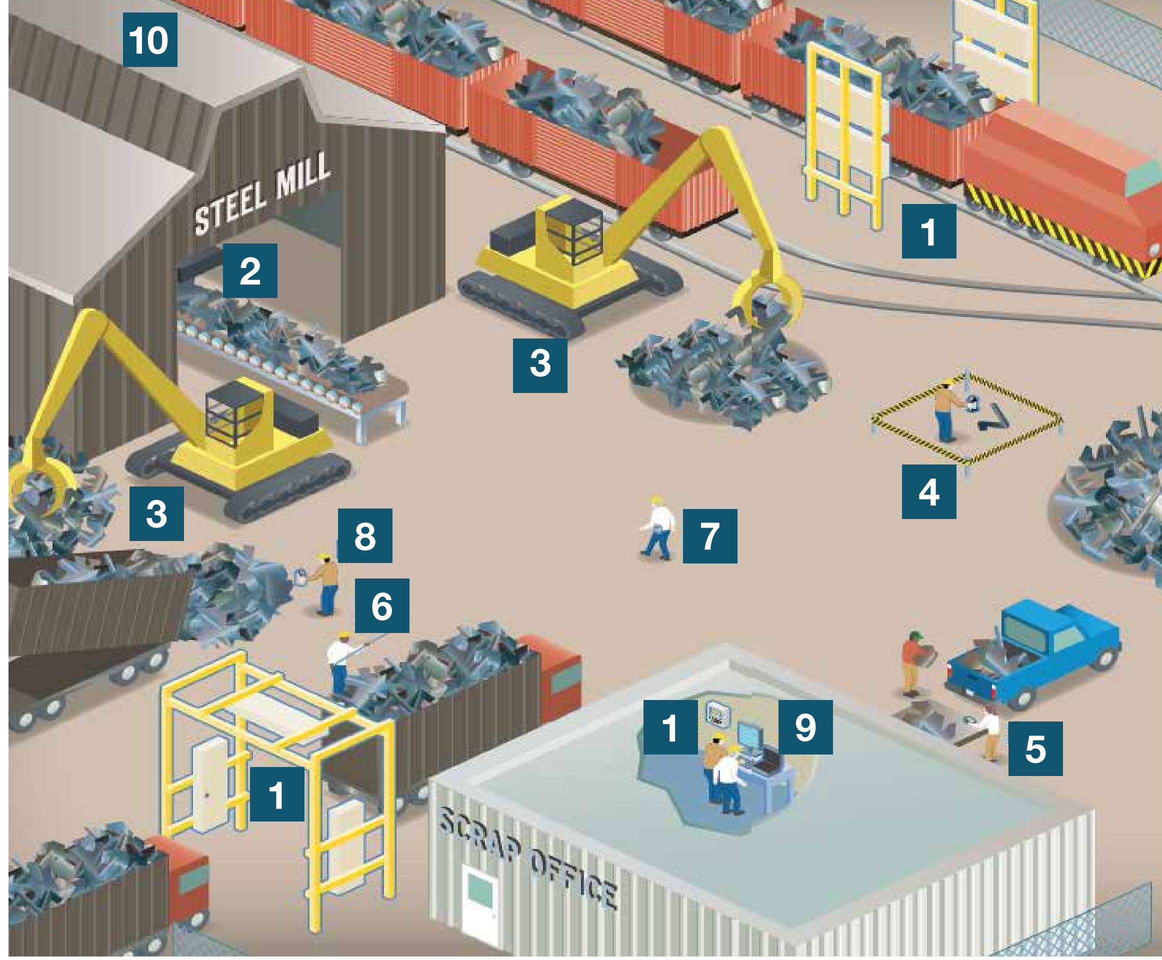
Time **Distance** **Shielding**

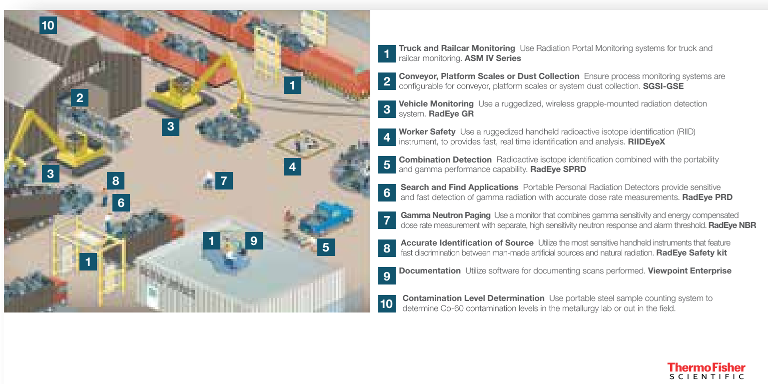
Did you know?

While the radiation emitted from a portable XRF analyzer is similar to the exposure received in a normal medical or dental X-ray, care must be taken to always point a handheld XRF analyzer directly at the sample and never at a person or a body part.

7 Keep your facility and your products safe from radiation

Undesirable radioactive sources (from old medical equipment, density gauges, etc.) can frequently show up at metal processing facilities, threatening the safety of employees, products, and resulting in expensive plant decontamination and shut down. Multiple points of inspection are necessary in the workflow to ensure processed materials are free from radioactive sources





1 **Truck and Railcar Monitoring** Use Radiation Portal Monitoring systems for truck and railcar monitoring. **ASM IV Series**

2 **Conveyor, Platform Scales or Dust Collection** Ensure process monitoring systems are configurable for conveyor, platform scales or system dust collection. **SGSI-GSE**

3 **Vehicle Monitoring** Use a ruggedized, wireless grapple-mounted radiation detection system. **RadEye GR**

4 **Worker Safety** Use a ruggedized handheld radioactive isotope identification (RIID) instrument, to provides fast, real time identification and analysis. **RIIDEyeX**

5 **Combination Detection** Radioactive isotope identification combined with the portability and gamma performance capability. **RadEye SPRD**

6 **Search and Find Applications** Portable Personal Radiation Detectors provide sensitive and fast detection of gamma radiation with accurate dose rate measurements. **RadEye PRD**

7 **Gamma Neutron Paging** Use a monitor that combines gamma sensitivity and energy compensated dose rate measurement with separate, high sensitivity neutron response and alarm threshold. **RadEye NBR**

8 **Accurate Identification of Source** Utilize the most sensitive handheld instruments that feature fast discrimination between man-made artificial sources and natural radiation. **RadEye Safety kit**

9 **Documentation** Utilize software for documenting scans performed. **Viewpoint Enterprise**

10 **Contamination Level Determination** Use portable steel sample counting system to determine Co-60 contamination levels in the metallurgy lab or out in the field.

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Download the infographic:
10 areas metal processors require radiation detection

Technology

What is XRF?

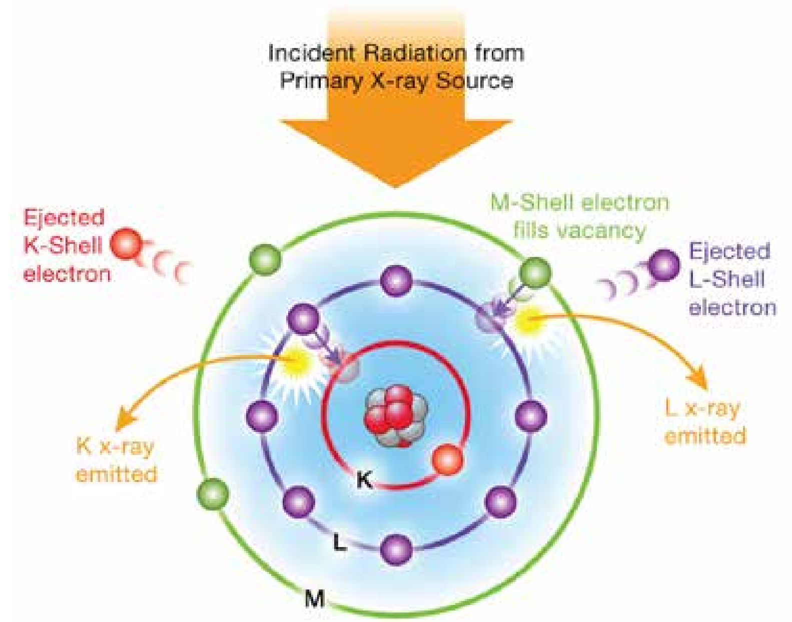
X-ray fluorescence (XRF): a non-destructive analytical technique used to determine the chemical composition of materials

Fingerprints

Each of the elements present in a sample produces a unique set of characteristic X-rays that is a “fingerprint” for that specific element.

Download the eBook

The X-ray fluorescence process



1. A solid or a liquid sample is irradiated with high energy X-rays from a controlled X-ray tube.
2. 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.
3. 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.
4. 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.

List of periodic table elements

1 Hydrogen	**H**	21 Scandium	**Sc**	41 Niobium	**Nb**	61 Promethium	**Pm**	81 Thallium	**Tl**	101 Mendelevium
2 Helium	**He**	22 Titanium	**Ti**	42 Molybdenum	**Mo**	62 Samarium	**Sm**	82 Lead	**Pb**	102 Nobelium
3 Lithium	**Li**	23 Vanadium	**V**	43 Technetium	**Tc**	63 Europium	**Eu**	83 Bismuth	**Bi**	103 Lawrencium
4 Beryllium	**Be**	24 Chromium	**Cr**	44 Ruthenium	**Ru**	64 Gadolinium	**Gd**	84 Polonium	**Po**	104 Rutherfordium
5 Boron	**B**	25 Manganese	**Mn**	45 Rhodium	**Rh**	65 Terbium	**Tb**	85 Astatine	**At**	105 Dubnium
6 Carbon	**C**	26 Iron	**Fe**	46 Palladium	**Pd**	66 Dysprosium	**Dy**	86 Radon	**Rn**	106 Seaborgium
7 Nitrogen	**N**	27 Cobalt	**Co**	47 Silver	**Ag**	67 Holmium	**Ho**	87 Francium	**Fr**	107 Bohrium
8 Oxygen	**O**	28 Nickel	**Ni**	48 Cadmium	**Cd**	68 Erbium	**Er**	88 Radium	**Ra**	108 Hassium
9 Fluorine	**F**	29 Copper	**Cu**	49 Indium	**In**	69 Thulium	**Tm**	89 Actinium	**Ac**	109 Meitnerium
10 Neon	**Ne**	30 Zinc	**Zn**	50 Tin	**Sn**	70 Ytterbium	**Yb**	90 Thorium	**Th**	110 Darmstadtium
11 Sodium	**Na**	31 Gallium	**Ga**	51 Antimony	**Sb**	71 Lutetium	**Lu**	91 Protactinium	**Pa**	111 Roentgenium
12 Magnesium	**Mg**	32 Germanium	**Ge**	52 Tellurium	**Te**	72 Hafnium	**Hf**	92 Uranium	**U**	112 Copernicium
13 Aluminum	**Al**	33 Arsenic	**As**	53 Iodine	**I**	73 Tantalum	**Ta**	93 Neptunium	**Np**	113 Ununtrium
14 Silicon	**Si**	34 Selenium	**Se**	54 Xenon	**Xe**	74 Tungsten	**W**	94 Plutonium	**Pu**	114 Flerovium
15 Phosphorus	**P**	35 Bromine	**Br**	55 Cesium	**Cs**	75 Rhenium	**Re**	95 Americium	**Am**	115 Ununpentium
16 Sulfur	**S**	36 Krypton	**Kr**	56 Barium	**Ba**	76 Osmium	**Os**	96 Curium	**Cm**	116 Livermorium
17 Chlorine	**Cl**	37 Rubidium	**Rb**	57 Lanthanum	**La**	77 Iridium	**Ir**	97 Berkelium	**Bk**	
18 Argon	**Ar**	38 Strontium	**Sr**	58 Cerium	**Ce**	78 Platinum	**Pt**	98 Californium	**Cf**	
19 Potassium	**K**	39 Yttrium	**Y**	59 Praseodymium	**Pr**	79 Gold	**Au**	99 Einsteinium	**Es**	
20 Calcium	**Ca**	40 Zirconium	**Zr**	60 Neodymium	**Nd**	80 Mercury	**Hg**	100 Fermium	**Fm**	

Handheld XRF instrument

Working principle

1

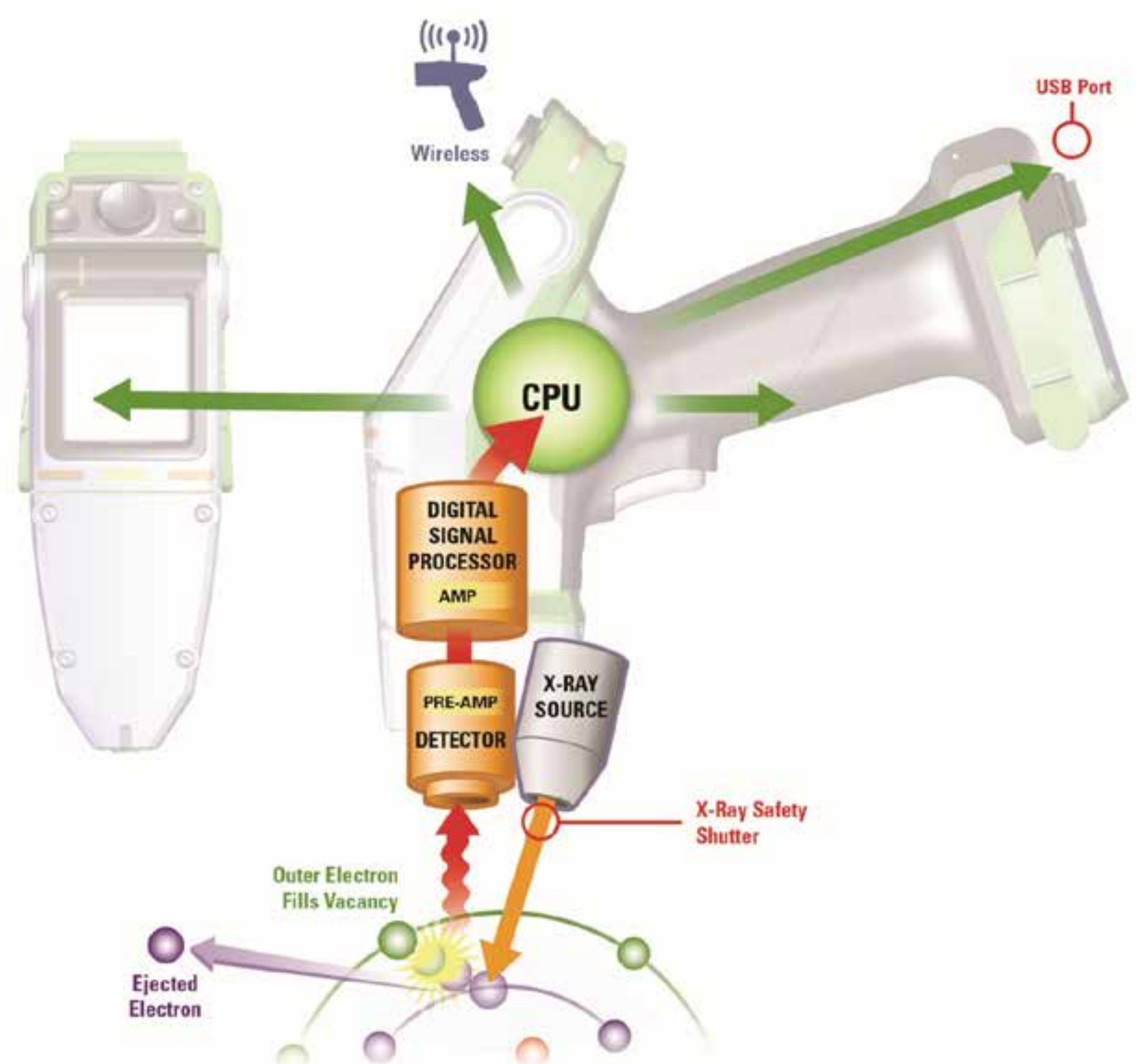
A sample is irradiated with high energy X-rays from a controlled X-ray tube. The energy causes inner-shell electrons to be ejected. Outer-shell electrons fill the vacancies and fluorescent x-rays are emitted.

2

The fluorescent x-rays enter the detector and send electronic pulses to the preamp. The preamp amplifies the signals and sends them to the Digital Signal Processor (DSP) to collect and digitize the x-ray events into channels of energy. Next, the “counts” for each channel (spectral data) is then sent to the main CPU for processing.

3

Using algorithms, the central processing unit (CPU) analyzes the spectral data and determines the concentration of each element present. Composition data and identified alloy grade are displayed in real time and stored via memory for later recall or download to an external PC.

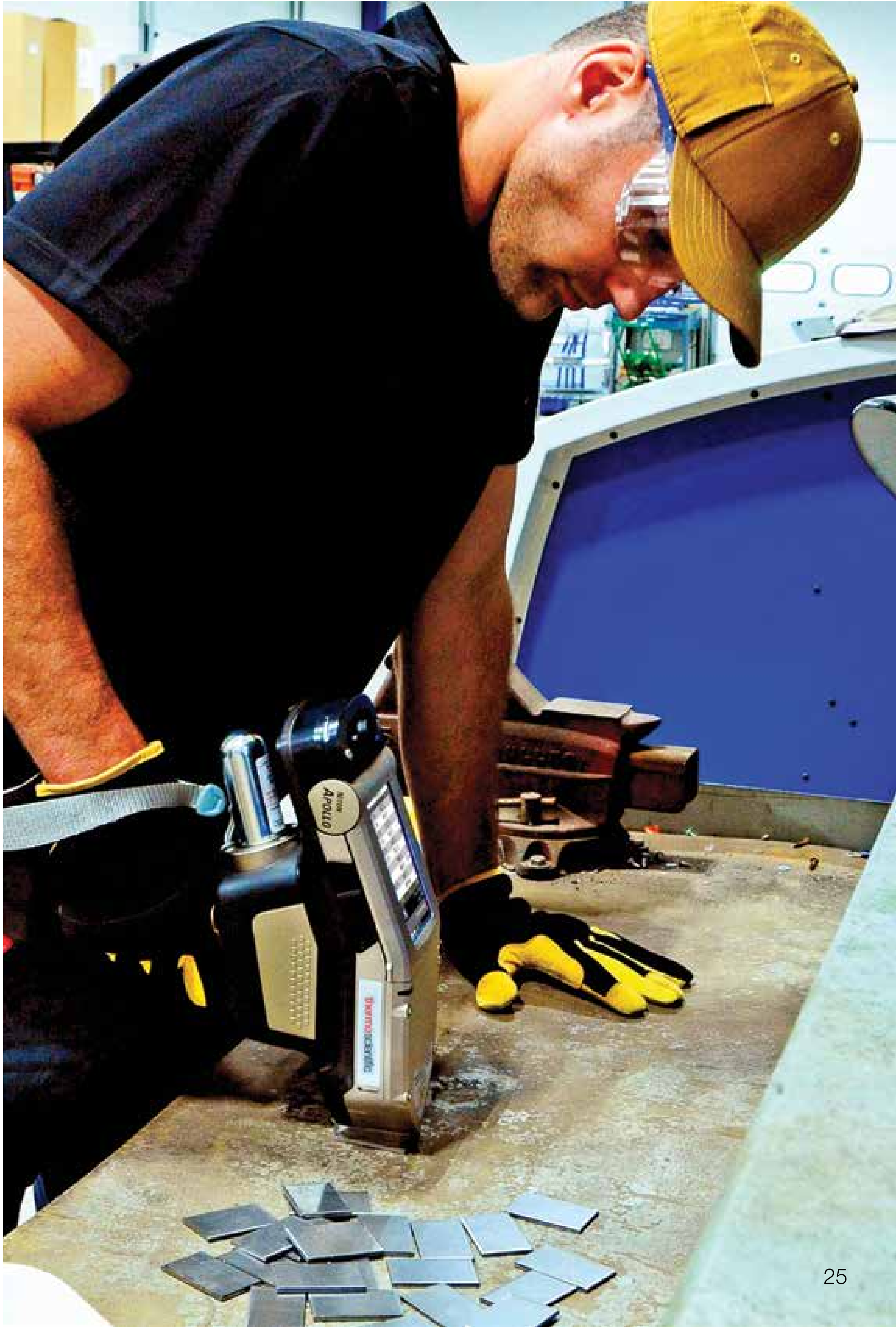


What is LIBS?

Overview

Laser Induced Breakdown Spectroscopy (LIBS) is the analytical technique using a high-focused laser to determine the chemical composition of materials. LIBS has been around for many years and is a technique used primarily in laboratory equipment. With recent advances in technology, the technique has now been developed into a portable handheld analyzer capable of measuring elements, including carbon, in the field for material identification.

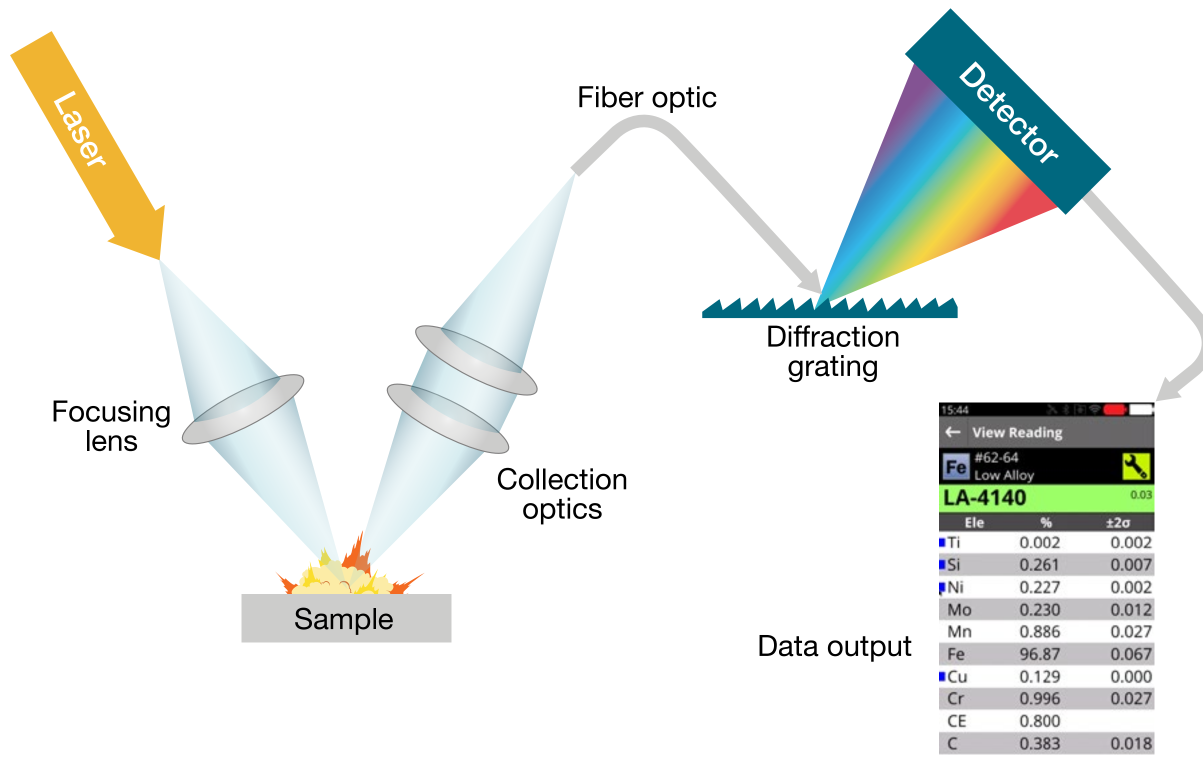
[Download the eBook]



The LIBS analysis process

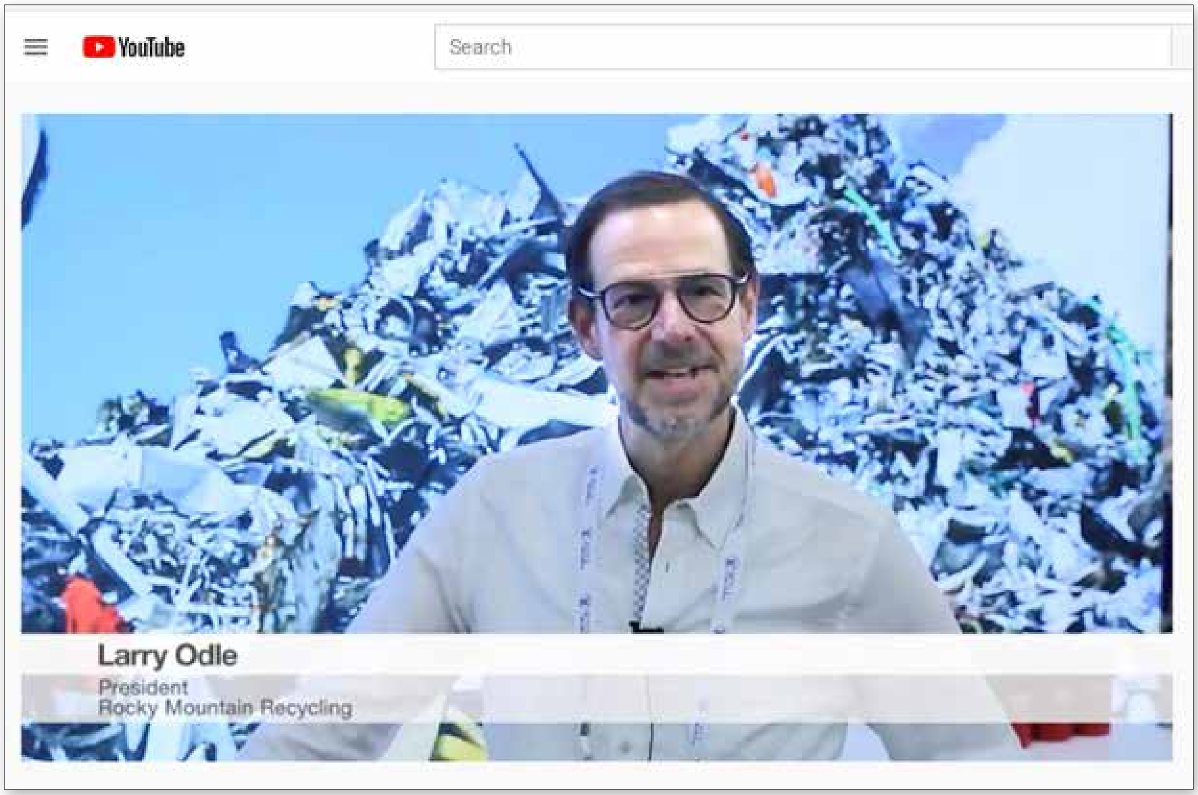
The LIBS technique utilizes a high-focused laser that interacts with the surface of a material and forms a plasma in which the material is broken down into single elements.

1. A laser pulse is produced by the analyzer and pointed at the sample surface.
2. The surface is ablated and forms a plasma. The plasma atomizes and excites the elements contained in the sample, emitting 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.



Experience with handheld XRF

How Rocky Mountain Recycling utilizes handheld XRF to sort, verify, and upgrade scrap metal



Watch this customer experience

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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 cleaner, healthier 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.

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