

A photograph showing a large, industrial metal sorting machine with a red and black claw mechanism, positioned over a large pile of scrap metal. The machine is suspended by a chain and hook, and the scrap metal consists of various pieces of metal, including what appears to be a large metal drum or tank. The background is a clear blue sky.

Scrap Metal Sorting With the SPECTRO xSORT Handheld XRF Spectrometer

The Key to Profitable Metals Recycling

Introduction

Hundreds of millions of tons of metal are recycled each year. Recycling conserves precious natural resources, and the benefits to the environment in saved energy and reduced greenhouse gas emissions are also well recognized. Scrap metal in a raw, unsorted form has low monetary value, is bulky and expensive to handle and transport, and attracts low

margins as a trade commodity. Manual sorting based on appearance, magnetic behavior and similar physical properties to identify higher value metals is labor intensive, inaccurate and unreliable. The SPECTRO xSORT handheld metals analyzer can take the uncertainty out of scrap sorting and positively identify alloy grades in seconds.

The role of scrap sorting in metals recycling

Metals, unlike many other materials, can be recycled without changing their physical properties, so properly recycled “secondary” metals can be used in place of “primary” metals produced from naturally occurring ores, and an increasing proportion of world metal production is from recycled metal. Clearly the most efficient way of recycling a metal alloy is to take scrap material of known composition and simply remelt it. While it is possible to adjust the composition of metals during the melt, this can be hugely wasteful in energy and time, so from a metal processor’s point of view it is important to be able to identify scrap metals as accurately as possible before they are processed.



The composition of an alloy can dramatically affect its properties and hence its value. Taking stainless steels as an example, two of the most popular are Types 304 and 316. Type 316 is substantially more resistant to corrosion than Type 304, and for that reason commands a higher price, typically 35%. This differential is reflected in the scrap price. While it is possible to differentiate between these grades on the basis of their magnetic properties, this is unreliable as the mechanical history of the metal – forging, rolling etc. - can affect its magnetic behavior. Both steels contain similar amounts of chromium and nickel, but Type 316 contains up to 3% molybdenum whereas Type 304 contains little or none. Measuring the molybdenum content by chemical analysis is the only sure way of differentiating these two alloys.

Even when alloys are fundamentally different identification can still be a problem. For example some titanium alloys appear very like stainless steel on visual inspection. Of course the density is very different, but it may not be possible to pick up the item to check it. Titanium alloy scrap could be worth up to three times more than even high grade stainless steel.

The ability to analyze scrap metals can add value at all stages of the recycling process, The scrap dealer can sort mixed scrap of very low value into selected materials commanding higher prices, and the processor can better control

the input to the process and the quality of the output. In international scrap trading, analysis may be needed to classify scrap according to the Institute of Scrap Recycling Industries Inc. (ISRI) specifications. The volatility of metal prices is notorious. A political event on the other side of the world could create a sudden shortage of a particular alloying element, driving up prices. Economic factors can cause demand to accelerate or to collapse. The ability to identify and separate high and low value materials is key to profitable metals recycling.

The challenge

The only certain way of identifying scrap metals is by elemental analysis. Many analytical techniques require samples to be analyzed in the laboratory, but this is usually impractical for scrap sorting as it takes far too much time and in any case is usually very expensive in relation to the value of the material being tested. Very often, the price paid for scrap is agreed when the consignment arrives at a dealer's premises, so very fast analysis is required. Similarly, a consignment may contain many different items, so a large number of analyses is needed in a short time for the final result to be representative. Usually scrap comes in a variety of shapes and sizes, so any technique used must be able to cope with this as well. The ideal equipment should be simple to use on site by non-scientifically trained personnel, and be portable. Minimal sample preparation should be required. Small, hand-held

X-ray Fluorescence (XRF) spectrometers can satisfy all these requirements, and the SPECTRO xSORT handheld instrument employs the latest XRF technology to provide a comprehensive solution for sorting metal scrap.

XRF basics

The design, performance and simple operation of the SPECTRO xSORT handheld X-ray fluorescence spectrometer make it ideal for scrap sorting. XRF spectrometry is a well proven technique for metals analysis, popular since its introduction in the 1950's. Large high performance XRF spectrometers are a standard tool for quality control analysis in most major metal processing facilities.

The technique works by irradiating the surface of the sample with a beam of X-rays. This induces fluorescence in the atoms in the sample, which is then re-emitted as X-rays of a lower energy. Each element emits X-rays of a different and unique energy or wavelength, whose intensity is proportional to the concentration of that element in the sample. Detection systems have been developed that can discriminate between the energies emitted, measure their intensities and hence determine the concentration of the different elements in the sample. This technology is known as Energy Dispersive X-ray Fluorescence, or ED-XRF.

SPECTRO Analytical Instruments has supplied X-ray spectrometers to the

metallurgical industries for many years and that experience is built into the xSORT handheld XRF spectrometer.

Scrap sorting with SPECTRO xSORT

The SPECTRO xSORT can discriminate quickly and easily between alloy types and also identify specific alloys within those groups. Examples of alloys that can be identified with SPECTRO xSORT are:

- Iron alloys (e.g. low alloy, stainless, high-temperature steels and tool steels)
- Nickel alloys (including those with hafnium, tantalum or rhenium as alloying elements) and cobalt alloys
- Titanium alloys
- Copper and zinc alloys
- Various wrought aluminum alloys
- Chrome-molybdenum steels

The SPECTRO xSORT has been optimized for fatigue-free on site analysis. Complete with battery pack, the x-SORT weighs less than 4 pounds (1.6 kg) and has an ergonomically designed handle and grip. All that is necessary is to bring the instrument into contact with the surface of the test sample and press the trigger. The user interface and results are displayed on an optimally positioned touchscreen. The instrument is robust, its housing made from shock-resistant ABS plastic. When not in use it can be carried in a convenient holster.

Results are displayed on the touchscreen either as a complete analysis, or the instrument can compare the analysis with

its extensive internal alloy library and display the alloy ID direct:



Even more convenient in some situations, it can give a simple Pass/Fail message using the first sample measured as a reference.

A typical example is the identification of stainless steels. As mentioned above, Type 304 stainless steel differs from Type 316 principally in its molybdenum content. The results below were obtained with three two-second “point-and-shoot” measurements with the SPECTRO xSORT, but a single measurement would suffice to identify the alloy.

AISI 304			
Element	Measurement time: 2 Sec		
	Certified Value [%]	Average Value [%]	2 * SD [%]
Mn	1.83	1.90	0.05
Cr	18.58	18.67	0.08
Mo	0.35	0.38	0.012
Ni	8.09	8.03	0.08
Cu	0.42	0.46	0.029

AISI 316			
Element	Measurement time: 2 Sec		
	Certified Value [%]	Average Value [%]	2 * SD [%]
Mn	1.78	1.88	0.08
Cr	16.56	16.57	0.08
Mo	2.11	2.20	0.06
Ni	10.38	10.49	0.14
Cu	0.17	0.18	0.038

[Note: The “2*SD” indicates the precision of the analysis. For an explanation and discussion of the instrumental factors involved, see Appendix].

The difference in the molybdenum content can be clearly seen

SPECTRO xSORT delivers metal (alloy) grade identification and material verification in only 2 seconds for most alloys, and can even identify alloys based on challenging light elements such as aluminum, magnesium, and silicon in 7 seconds.

All these results can be stored or sent wirelessly (Wifi, Bluetooth) to an external printer or PC.

Calibration of the instrument is automatic using stored calibrations combined with SPECTRO’s iCAL (Intelligent Calibration Logic). With any XRF instrument stored calibrations must be periodically checked against a known standard. The SPECTRO xSORT is fitted with an automatic shutter that closes between each measurement, partly to protect internal components and partly to protect the operator from possible exposure to X-rays. iCAL ingeniously uses the shutter itself (i.e. when it is closed) as the external standard and checks the calibration between measurements. No operator intervention is required as any necessary adjustments are made automatically.

Little sample preparation is normally required. Oil or grease on the surface of the sample can simply be wiped away. However some surface conditions and finishes could cause errors, partly because the SPECTRO xSORT will analyze what is on the surface as well as the underlying metal. These problems can usually be overcome by grinding back the surface using a suitable abrasive. Examples where this might be necessary include:

- Heavily oxidized, uneven or scaled surfaces
- Plated parts, e.g. Ni or Zn on steel
- Shot blasted parts, as traces of the shot material can be deposited on the surface of the item
- Painted or plastic coated items.

When X-rays are employed, operator safety is an important consideration. The role of the automatic shutter in protecting the operator has already been mentioned, and as an added safety feature the

SPECTRO xSORT recognizes in a fraction of a second if no sample is present and closes the shutter automatically to cut off the X-rays. There are also LEDs on the side and on the top of the instrument to tell the operator and others in the vicinity when the X-ray tube is activated and a measurement in progress. A safety gasket surrounds the active measurement area to protect the operator from any stray X-rays. When small or thin samples such as wire are being analyzed, there is the risk that X-rays could escape past the sample. Therefore, a portable sample chamber or a docking station are optionally available for small samples to prevent this happening.

Conclusion

The SPECTRO xSORT handheld ED-XRF analyzer is an easy to use but highly dependable and accurate tool for sorting metallic scrap, and presents the opportunity to add value and increase profitability at all stages of the recycling process.



APPENDIX

For those requiring background information on the technical aspects of the SPECTRO xSORT.

Analyzer

The measurements discussed in this paper were made using a SPECTRO xSORT handheld XRF spectrometer from SPECTRO Analytical Instruments. The company has supplied X-ray spectrometers to the metallurgical industries for many years; that experience is built into the SPECTRO xSORT line. This analyzer is a member of the SPECTRO xSORT family of instruments, which offers reliable on-site identification, analysis, and screening for every budget. It's designed to provide ensured PMI results, positively identifying steels in seconds.

The SPECTRO xSORT utilizes a miniaturized, low-power X-ray tube rated at 50 kilovolts (kV), with a rhodium anode, providing exactly defined excitation for excellent stability and precision. This is complemented by a high-count readout system and a high-resolution, high-sensitivity silicon drift detector (SDD). (These technologies are versions of those used in high-performance laboratory instruments like the top-of-the-line SPECTRO XEPOS analyzer.) They're combined to enable the handheld SPECTRO xSORT to furnish accurate, high-productivity spectrochemical analysis of metals for PMI applications.

The SPECTRO xSORT used is field-proven to deliver grade analysis in only 2 seconds for many metals and alloys.

Efficient ergonomics plus simple, user-friendly displays help make the instrument extremely easy to use. Complete with battery pack, SPECTRO xSORT weighs less than 4 pounds (1.6 kilograms). To operate, the user grips the comfortable handle, presses the flexible X-ray safety gasket onto the sample, and pulls the trigger.

The instrument's unique iCAL logic supplies easy one-sample, one-time standardization. Analytical results are clearly displayed on an integrated touchscreen. They can also be saved simultaneously to an SD card, network, or printer in XML or PDF form (WiFi capability is standard). An optional integrated camera for precise spot testing can also pair each result with an image of the subject sample. With a second optional overview camera, pictures of the testing location or barcodes and QR codes can be added to the result. A large, flexible metals database easily accommodates new alloys, and lets the user extend prepackaged libraries or create customized grade libraries.

Finally, the instrument's automatic shutter fulfills two purposes: to protect internal components, and also to serve as sample material for the iCAL standardization. No separate sample or tedious operator standardization routine is required.

Within the comprehensive SPECTRO family of advanced elemental analyzers,

SPECTRO xSORT is the preferred choice for fast, easy, and accurate PMI analysis across numerous industries

Design for performance

The two components that define the fundamental performance of an ED-XRF system are the X-ray source and the detector. The stability of the primary source of X-rays affects both the ultimate detection limit of the instrument and the precision of the analysis. In the SPECTRO xSORT a miniaturized low power X-ray tube, a close relative of those used in SPECTRO's high performance laboratory analyzers, ensures exactly defined excitation and hence good precision. The detector used in the SPECTRO xSORT is an advanced Silicon Drift Detector, or SDD. Compared to the Si PIN diode detectors used in entry-level instruments, the SDD displays better resolution (ability to discriminate between elements) and can process information ten times faster, giving faster analysis.

Precision and Limits of Detection

The concentration values in the given examples are expressed as percentages, and the precision of the measurement is expressed by SD or $2*SD$, also in percent concentration. SD is the Standard Deviation of a number of measurements and indicates the spread of the data about the average (or mean) result. The smaller the SD, the better the precision of the measurement. $2*SD$, also known as "two sigma" is twice the standard deviation and indicates that 95% of readings will

fall within this range. In the examples given these values are calculated on the basis of three separate measurements, but the SPECTRO xSORT can also use the data collected during a single measurement to calculate an SD. Clearly any concentration reported that is of the same magnitude as the measurement error is going to be unreliable, which leads to the concept of Limit Of Detection or LOD, the lowest concentration that can be reliably measured. SPECTRO xSORT can be set up to either display the < symbol, or not to report a result, if it detects a concentration lower than the LOD.

An application report detailing xSORT's performance for all common metal matrices and elements can be requested at spectro.com.

Choosing a handheld XRF analyzer

Handheld XRF spectrometers are not created equal. Make sure the instruments you consider can meet the needs of your specific PMI tasks with the right mix of proven performance, innovative features, and tested convenience. Look for the following benefits:

Field-proven performance and speed. Consider models that have proved they can perform well in challenging plant or field locations. One key for highly reliable yet high-volume PMI: the ability to deliver reliable results in seconds.

Documentation/connection flexibility. Why get stuck with limited choice of results formats to document compliance? Flexible SPECTRO xSORT lets you save results in different formats at different destinations simultaneously. Save to SD card, network, or printer as XML or PDF, and (via an integrated camera) combine with images of the sample measured.

Easy standardization and built-in protection. Try to find instruments that avoid tedious multiple-sample standardization. Example: SPECTRO xSORT provides unique one-sample, one-time standardization. The shutter even functions as the system's standardization sample, while also offering built-in protection of detector and tube.

Large metals database. Choose devices that can easily accommodate new alloys (e.g., with light elements) or materials. For instance, SPECTRO xSORT lets you extend prepackaged libraries and/or create new customized grade libraries.



CONTACT US



REQUEST A QUICK QUOTE



REQUEST A FREE DEMO



RESOURCE LIBRARY



FEEDBACK

www.spectro.com



GERMANY

SPECTRO Analytical Instruments GmbH
Boschstrasse 10
D-47533 Kleve
Tel. +49.2821.892.0
spectro.sales@ametek.com

U.S.A.

SPECTRO Analytical Instruments Inc.
50 Fordham Rd
Wilmington 01887, MA
Tel. +1 800 548 5809
+1 201 642 3000
spectro-usa.sales@ametek.com

CHINA

AMETEK Commercial
Enterprise (Shanghai) CO., LTD.
Part A1, A4 2nd Floor Building No. 1 Plot Section
No. 526 Fute 3rd Road East; Pilot Free Trade Zone
200131 Shanghai
Tel. +86.400.022.7699
spectro-china.sales@ametek.com

Subsidiaries:

► **FRANCE:** Tel. +33.1.3068.8970, spectro-france.sales@ametek.com ► **GREAT BRITAIN:** Tel. +44.1162.462.950, spectro-uk.sales@ametek.com
► **INDIA:** Tel. +91.22.6196.8200, sales.spectroindia@ametek.com ► **ITALY:** Tel. +39.02.94693.1, spectro-italy.sales@ametek.com
► **JAPAN:** Tel. +81.3.6809.2405, spectro-japan.info@ametek.co.jp ► **SOUTH AFRICA:** Tel. +27.11.979.4241, spectro-za.sales@ametek.com

SPECTRO operates worldwide and is present in more than 50 countries. For SPECTRO near you, please visit www.spectro.com/worldwide

© 2024 AMETEK Inc., all rights reserved, subject to technical modifications • H-24 • Rev.3 • Photos: SPECTRO, Adobe Stock

Registered trademarks of SPECTRO Analytical Instruments GmbH •  SPECTRO: USA (3,645,267); EU (005673694); "SPECTRO": EU (009693763); xSORT: USA (IR 3,767,555); Japan, China (IR 978 588); EU (007058456) "SPECTROTEST": USA (4,103,718), EU (004206173)