SPECTRO

Aluminum Recycling - Add Value by Analysis

Mobile Spectrometers for Easy Analysis and Identification of Aluminum Alloys

Recycling aluminum alloys is beneficial both financially and environmentally and has become a major industry in its own right. There are two major reasons for this: firstly, aluminum alloys are particularly amenable to recycling and can be recycled many times without losing their properties and secondly, huge energy savings are possible as recycling uses only 5% of the energy required to extract and refine new aluminum. Many specialized aluminum alloys have been developed for applications such as aviation and the automotive industry and these command premium prices, both as new material and scrap. It is therefore in the best interest of the recycler to identify input material and separate the various grades before processing. This is best done by elemental analysis. Laboratory analysis is sometimes not feasible or necessary and expensive and can involve unacceptable delays. But modern mobile and portable analyzers are available that can handle the necessary analyses on site to provide accurate and positive material identification even when used by non-specialist operators. This paper describes two such instruments from SPECTRO Analytical Instruments, the SPECTRO xSORT hand-held metals analyzer and the SPECTROTEST mobile emission spectrometer, and their application to the analysis of aluminum alloys.

PRIMARY ALUMINUM

Aluminum (or Aluminium, both names are accepted by IUPAC) is the most abundant metallic element in the earth's crust, but was unknown in its metallic form until the early 19th century. This is because of the difficulty of extracting the metal from its ores. Most early extraction metallurgy (e.g. for Fe) involved reduction of the oxide ores with carbon, but this is not possible for Al because Al is a stronger reducing agent than carbon. Virtually all primary Al production is by the electrolytic reduction of aluminum oxide Al_2O_3 prepared from the principal ore, bauxite. Bauxite is an impure mineral typically containing less than 50% Al_2O_3, which is first extracted from the mineral using a hot sodium hydroxide extraction followed by precipitation and subsequent calcination. The purified Al_2O_3 is then electrolyzed between graphite electrodes using molten synthetic Cryolite (Na_3AlF_6) as a flux and with AlF_3 added to lower the melting point of the mixture. Electrolysis is carried out at a temperature approaching 1000°C and using currents of thousands of amperes. Clearly, such a process is very capital intensive and immensely costly to run in terms of electrical power, which can represent up to 40% of the cost of the aluminum. The increasing cost of energy and the environmental pressure on its consumption are major drivers for recycling aluminum and its alloys. Recycling requires only 5% of the energy required to produce primary aluminum.

AMETEK® MATERIALS ANALYSIS DIVISION

Aluminum alloys and their uses

Pure aluminum is relatively soft and mechanically weak, although in its pure form it does have good corrosion resistance and its strength can be increased by mechanical processing such as cold-rolling. Alloying with other metals like Cu, Zn, Mg, Mn, Si and Li, can however produce engineering materials that are very light while having high tensile strength that can approach that of steel. This combination of properties has led to the very extensive use of aluminum alloys in aerospace and in the automotive industries for such applications as cylinder heads, wheels and lightweight body components. They are used in the construction industry, both as structural components and for extruded window frames and the like. Cooking and other domestic utensils and the ubiquitous aluminum drinks can are also major consumers.

For some of the more demanding applications, as in aerospace or where corrosion resistance is a major factor, the elemental composition of the alloy is critical. Hundreds of specialized alloys have been developed for different purposes, and various classification systems have been created to describe them. One of the most widely used is the International Alloy Designation System (IADS), based on the classification developed by the Aluminum Association of the United States. The system used as series of 4-digit numbers, the first of which indicates the major alloying element and the others are used to identify the specific alloy (see table 1).

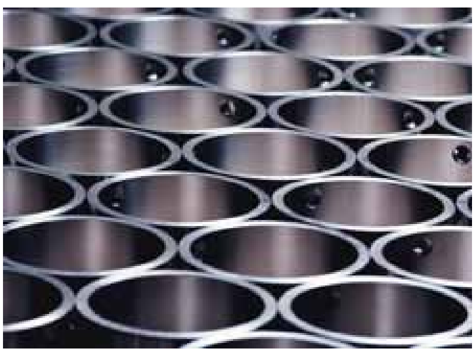


Table 1: International Alloy by Designation System (IADS)

Series	Major alloying element(s)	Typical Properties	Typical Application
1xxx	Pure Al (>99%)	Good electrical conductivity, flexible	Electrical cable, packaging foil
2xxx	Cu	High strength	Aircraft structures, automotive bodies
3xxx	Mn	Formability, corrosion resistance	Beverage cans, cooking utensils, construction
4xxx	Si	Good flow characteristics	Forgings, welding alloys
5xxx	Mg	Strength, good corrosion resistance	Construction, storage tanks, marine
6xxx	Mg, Si	High strength, extrudability	Extruded construction & automotive components
7xxx	Zn	Very high stength	Critical aircraft structures
8xxx	Others including Li*	Depends on alloying elements	Special applications

*Al/Li alloys have exceptional strength/weight characteristics and are increasingly used in aerospace applications

In each category, other minor alloying elements are used to achieve performance variations as required. The above classifications cover wrought alloys: another, and very similar series is used to describe casting alloys. This has the format 1xx.x, 2xx.x etc and again the first digit indicates the major alloying element. The next two digits identify the alloy, and the last indicates if it is a casting or an ingot.

Table 2: Casting Alloys

Series	Major alloying elements
1xx.x	Pure Al (>99%)
2xx.x	Cu
3xx.x	Si, Cu, Mg
4xx.x	Si
5xx.x	Mg
6xx.x	Unused
7xx.x	Zn
8xx.x	Sn
9xx.x	Others

Generally, the properties of these alloys mirror those of the equivalent wrought alloys. The 8xx.x series of Al/Sn alloys are materials with very good wear resistance and are used for slide bearings and similar applications.

Other standards exist in different countries and there are other classifications to indicate heat treatments and other processes that have been applied to the material.

With this multitude of different alloys with widely differing properties, recycling waste aluminum by simple re-melting of unsorted waste metal is clearly not very efficient – the composite melt may need considerable processing and metallurgy before secondary material with the desired properties can be produced. Some of the more specialized alloys command premium prices and treating these separately has obvious advantages. Sorting scrap and identifying the different alloys prior to melting adds value in aluminum recycling.

Aluminum Recycling

The aluminum recycling industry is mature and well developed. Since 2001 the production of secondary aluminum in the US from recycling has actually exceeded that of primary aluminum from smelting (source: USGS). A significant factor in this has been the aluminum beverage can, one of the most readily recycled aluminum products not least because the can industry itself provides a ready market for the recycled aluminum. The main benefits of aluminum recycling can be summarized as:

- Aluminum has unique recycling qualities: most alloys can be repeatedly remelted without loss of performance.
- Aluminum recycling saves energy: recycling saves up to 95% of the energy needed to pro duce the primary metal.
- Aluminum recycling is financially attractive: apart from the energy savings, a ready market exists for secondary aluminum.

The basic recycling process is very simple: the scrap is charged into a reverberatory furnace, melted and the molten metal cast into suitable ingots. Different types of scrap may require different treatments. The main types of scrap received for recycling are:

- In some countries UBC – Used beverage containers. Very often these can be part of a "closed loop" process, whereby the cans are simply melted to produce the metal needed for new cans.
- "New" scrap – waste material
- from the manufacture of aluminum articles. This may well be of known origin and composition.
- "Old" scrap - material that is recovered when an aluminum article has been discarded at the end of its useful life. Such scrap could be e.g. profiles, offset printing plates, automotive components such a cylinder heads and wheel rims, window frames, old electrical conductors, packaging scrap, aircraft components etc. Recent new legislation such as the European Community's ELV (End of Life Vehicles) Directive requires the environmentally responsible disposal of such materials and encourages recycling.
- Dross – this is the residue from other smelting and refining processes, usually heavily contaminated with other metals, and needing extensive processing to recover usable aluminum.

Clearly the level of processing required to handle these different types of scrap increases as the origin becomes less certain. The first two categories are normally handled by "remelters" whereas the others are processed by "re-refiners". The basic aluminum recycling process could be summarized as:

Scrap Collection and Sorting
↓
Scrap Trade
↓
Dismantling
Cleaning
Shredding
Separation
↓
Remelting/Refining

At each of these stages it is possible to add value by identifying and separating the different materials in the scrap. As mentioned before, aluminum alloys can be melted down and re-used without loss of their basic performance properties, so this is a real incentive to identify the alloy before remelting. In the case of "new" scrap this can be fairly straightforward provided an audit trail of the scrap material can be maintained. If this is not the case, or "old" scrap is being processed, physical examination of the scrap is rarely sufficient for a positive identification.

Because of the financial and environmental benefits of knowing scrap composition before remelting, there are now standards that can be applied to scrap quality. In the European Community, DIN EN 13920 identifies 15 different categories of aluminum scrap, specified in part by their overall elemental composition, and in the US, the Institute of Scrap recycling Industries (ISRI), also publishes aluminum scrap categories.

Most of these categories have limits on purity and on the content of various alloying and contaminant elements. For example scrap conforming to DIN EN 13920-2 would have an Al yield of 95% and the following maximum impurity levels: Si $\leq$0.25%, Fe $\leq$0.4%, Cu $\leq$0.05% Mn $\leq$0.05%, Mg $\leq$0.05%; Zn $\leq$0.07%, Ti $\leq$0.05%, others $\leq$0.05%. Clearly

The DIN EN 13920 categories are:

DIN EN 13920-2	Unalloyed Aluminum
DIN EN 13920-3	Wire and cable scrap
DIN EN 13920-4	Scrap consisting of one single wrought alloy
DIN EN 13920-5	Scrap consisting of two or more wrought alloys of the same series
DIN EN 13920-6	Scrap consisting of two or more wrought alloys
DIN EN 13920-7	Scrap consisting of castings
DIN EN 13920-8	Scrap consisting of non-ferrous materials from shredding processes destined to Aluminum separation processes
DIN EN 13920-9	Scrap from Aluminum separation processes of non-ferrous shredded materials
DIN EN 13920-10	Scrap consisting of used Aluminum beverage cans
DIN EN 13920-11	Scrap from aluminum-copper radiators
DIN EN 13920-12	Turnings consisting of one single alloy
DIN EN 13920-13	Mixed turnings consisting of two or more alloys
DIN EN 13920-14	Scrap from post-consumer aluminum packagings
DIN EN 13920-15	Decoated aluminum scrap from post-consumer aluminum packagings
DIN EN 13920-16	Scrap consisting of skimmings, drosses, spills and metallics

any scrap dealer or trader that can supply scrap conforming to these norms can command a higher price and commercial advantage. In some cases it may be possible to optimise the scrap for a particular customer by mixing materials of different grades, but it is clearly essential to have confidence in the properties of the available stock.

At the refiner, the issue of output quality also becomes important. Because of the importance of secondary aluminium, a number of "recycle friendly" alloy specifications have been developed to facilitate recycling. Some refiners produce alloys with deliberately high contents of alloying elements that can be blended with other alloys to produce the desired result. And of course the purchaser of the final secondary alloy will demand a specification and certificate of analysis.

In the initial stages of processing, at the scrap dealer or collector, magnetic separators are commonly used to differentiate between ferrous and non-ferrous scrap. These are not capable of differentiating aluminum from materials such as magnesium alloys or non-magnetic stainless steels, and they certainly cannot differentiate between the different alloys. The only reliable way of differentiating between the various alloys and discriminating between aluminum based materials and others 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 can take far too long if the laboratory is not on site and in any case is usually very expensive relative 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 these requirements, and the new SPECTRO xSORT hand held instrument employs the latest XRF technology to provide a comprehensive, easy-to-use solution for sorting metal scrap. For some requirements, like the analysis of Al/Li alloys, the answer may be the SPECTROTEST, a mobile Optical Emission Spectrometer that is also fully at home in the working conditions experienced in the scrap industry.

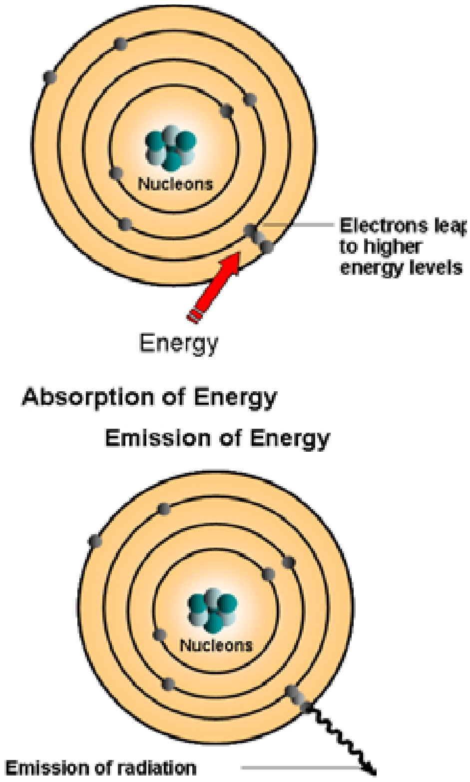
Instrumental Techniques for Alloy Identification

Energy Dispersive X-ray Fluorescence (EDXRF) and Optical Emission Spectrometry (OES) can be used by operators without analytical knowledge to return accurate analyses of even complex alloys in seconds rather than minutes or hours, and to give reliable alloy identification.

These techniques work on the spectroscopic principle, which relies on the internal structure of the atoms of the material being analyzed. The atoms of the sample are "excited" by an external source of energy, which is absorbed and raises the energy level of the electrons in the sample atoms. This "excited state" is unstable, and the electrons rapidly return to their normal state, re-emitting energy as they do so.

The energy emitted, or emission spectrum, is absolutely characteristic of the elements contained in the sample, and its intensity is proportional to their concentration.

The two techniques, EDXRF and OES, differ in the type of energy used to excite the sample atoms: in the former it is a beam of X-rays and in the latter it is an electric arc or spark. The relevant aspects of the instruments are covered below, but full descriptions of the fundamentals of EDXRF, and OES can be found in the e-learning modules on the SPECTRO website: www.spectro.com



The excitation of atoms by OES, with X-rays the inner electrons are "excited"

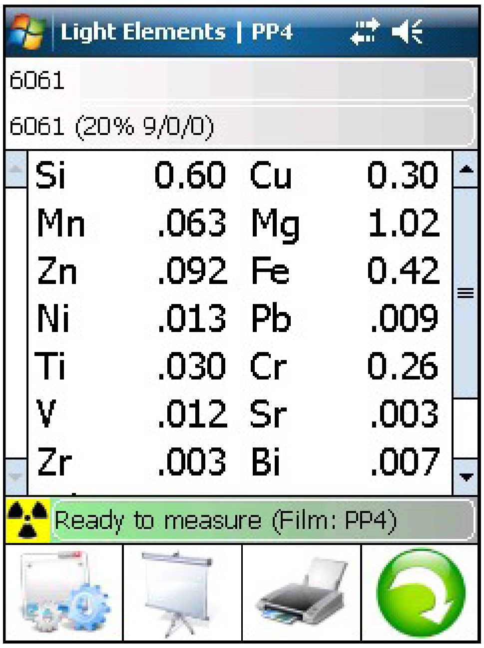
THE SPECTRO xSORT

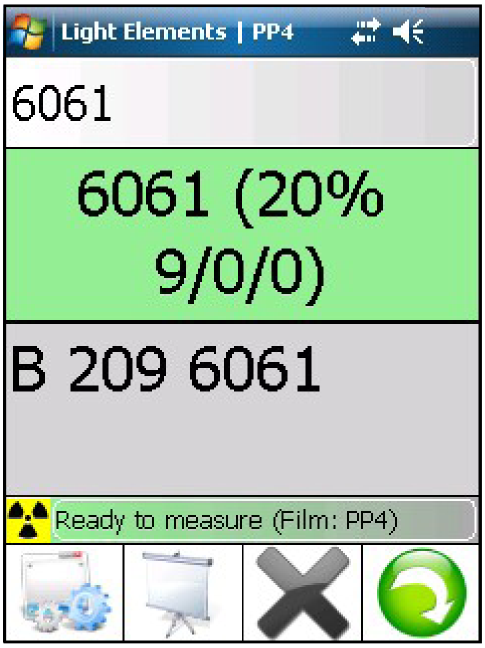
The design, performance and simple operation of the SPECTRO xSORT hand-held X-ray fluorescence spectrometer make it ideal for scrap sorting. XRF spectrometry is a well proven technique for metals analysis, popular since its introduction in the 1950's.

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 technologies have been developed that can discriminate between the fluorescent X-rays emitted, measure their intensities and hence determine the concentration of the different elements in the sample. SPECTRO Analytical Instruments has supplied X-ray spectrometers to the metallurgical industries for many years and that experience is built into the xSORT hand-held XRF spectrometer. xSORT can discriminate quickly and easily between alloy types and also identify specific alloys within those groups.

The xSORT has been optimized for fatigue-free on site analysis. Complete with battery pack, the x-SORT weighs less than 4 pounds (1.7 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 PDA. 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 PDA either as a complete analysis, or the instrument can compare the analysis with its extensive internal alloy library and display the grade direct:





All measurement results on the SPECTRO xSORT can be displayed with grade specifications.
The pre-defined grade library delivered with the instrument can be easily extended by adding data from the optional SPECTRO Metals Database. Even more convenient in some situations, xSORT can give a simple Pass/Fail message using the first sample measured as a reference. All these results can be stored in the instrument or sent to an external printer or PC via a wireless Bluetooth interface.
The instrument uses stored calibrations combined with SPECTRO's ICAL (Intelligent Calibration Logic). With any XRF instrument stored calibrations must be checked periodically against a known standard to standardise the system. The 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 this shutter (i.e. when it is closed) as the standard and checks the instrument status against it between sample measurements. No operator intervention is required as any necessary adjustments to the calibrations 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 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. "Alclad", a material used in aircraft construction, when the aluminum alloy is coated with a few microns of pure aluminum as corrosion protection
- 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 two LED's on the side 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. The measure window is 8mm in diameter, the beam spot just 3.5mm. When small or thin samples such as wire are being analyzed, there is the risk that X-rays could escape past the sample. A special adaptor is available for small samples to prevent this happening.
In many situations xSORT can provide an analysis of alloys in only 2 seconds. The "light" elements magnesium and silicon, are particularly important in aluminum metallurgy, and are more difficult to measure by XRF than "heavy" alloying elements like Cu and Zn. With just 10 seconds in addition the xSORT can differentiate between various al alloys and on the basis of their Mg content in 20 to 30s. It's a comfortable time to keep a hand-held instrument stationary on the sample, whereas other similar instruments may require 60s to achieve the required detection limits. The xSORT measures these light elements in air – it does not require the path of the X-Ray beam to be flushed with helium gas or to be under vacuum during the measurement.
The limits of detection of various elements in Al base are given in the following table. The following data are related to measurements of pure single element standards at a measuring time of 10s and 20s for Mg, Al, Si, P and S.

Table 3: Limit of Detection, LOD [%]

Element	LOD [%]
Ag	0.01
Bi	0.005
Cd	0.01
Co	0.01
Cr	0.02
Cu	0.004
Fe	0.01
Mg	0.4
Mn	0.01
Mo	0.002
Nb	0.003
Ni	0.003
Pb	0.006
Sb	0.03
Si	0.03
Sn	0.02
Ti	0.02
V	0.01
Zn	0.003
Zr	0.01

The following data show measured and certified values for various elements in typical aluminum alloys, and clearly show how the xSORT can discriminate between these different alloys, even on the basis of the more "difficult" elements like Mg and Si.

1100Al

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	10s	99.00		99.1
	20s	99.00		
	30s	99.10		
Cu	5s	0.130	0.003	0.14
Mn	5s	0.033	0.003	0.032
Zn	5s	0.036	0.001	0.029

2014AD

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	10s	92.40		92.89
	20s	92.80		
	30s	92.60		
Cu	5s	4.14	0.01	4.26
Fe	5s	0.43	0.01	0.46
Mg	10s	0.8	0.3	0.45
	20s	<0.5	0.3	
	30s	0.4	0.2	
Mn	5s	0.75	0.01	0.81
Si	10s	0.78	0.04	0.88
	20s	0.78	0.03	
	30s	0.85	0.02	
Ti	5s	0.021	0.002	0.030
Zn	5s	0.045	0.002	0.029

3003Al

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	10s	97.70		97.77
	20s	97.70		
	30s	97.60		
Cu	5s	0.071	0.003	0.085
Fe	5s	0.662	0.005	0.64
Mn	5s	1.071	0.006	1.10
Si	10s	0.22	0.03	0.25
	20s	0.26	0.02	
	30s	0.34	0.02	
Zn	5s	0.028	0.001	0.020

4145AB

Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	10s	85.20		84.24
	20s	85.10		
	30s	85.10		
Cr	5s	0.055	0.002	0.050
Cu	5s	3.97	0.01	4.12
Fe	5s	0.523	0.004	0.54
Mg	10s	<0.64		0.050
	20s	<0.45		
	30s	<0.37		
Mn	5s	0.018	0.003	0.050
Si	10s	10.0	0.1	10.66
	20s	10.10	0.07	
	30s	10.10	0.06	
Zn	5s	0.063	0.002	0.058

5083AF				
Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	10s	93.60		93.49
	20s	93.50		
	30s	93.70		
Cr	5s	0.162	0.003	0.15
Cu	5s	0.07	0.02	0.078
Fe	5s	0.333	0.004	0.34
Mg	10s	4.6	0.3	4.85
	20s	4.8	0.2	
	30s	4.5	0.2	
Mn	5s	0.781	0.005	0.74
Si	10s	0.22	0.03	0.17
	20s	0.21	0.02	
	30s	0.20	0.02	
Ti	5s	0.023	0.002	0.027
Zn	5s	0.066	0.001	0.050

6061SS				
Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	10s	97.60		97.81
	20s	97.20		
	30s	97.10		
Cr	5s	0.238	0.003	0.229
Cu	5s	0.301	0.003	0.30
Fe	5s	0.347	0.003	0.35
Mg	10s	0.7	0.3	1.00
	20s	1.0	0.2	
	30s	1.1	0.1	
Mn	5s	0.061	0.003	0.052
Si	10s	0.63	0.04	0.64
	20s	0.60	0.02	
	30s	0.63	0.02	
Ti	5s	0.028	0.002	0.037
Zn	5s	0.086	0.001	0.08

7075AF				
Element	Measurement time	Measured Value [%]	Standard Deviation [%]	Actual Value [%]
Al	10s	88.50		88.76
	20s	88.50		
	30s	88.20		
Cr	5s	0.222	0.004	0.22
Cu	5s	1.810	0.009	1.75
Fe	5s	0.143	0.004	0.17
Mg	10s	2.8	0.5	2.66
	20s	2.8	0.3	
	30s	3.1	0.3	
Mn	5s	0.048	0.004	0.031
Si	10s	0.27	0.03	0.19
	20s	0.26	0.02	
	30s	0.24	0.02	
Ti	5s	0.072	0.003	0.092
Zn	5s	5.56	0.01	5.75

THE SPECTROTEST

As these results show, the SPECTRO xSORT will be able to handle many scrap sorting tasks encountered aluminum recycling industry. When better precision is needed on the light elements like Mg and Si, or if Al/Li alloys are likely to be encountered, then the SPECTROTEST comes into its own. Al/Li alloys are a new generation of materials with exceptional strength/weight properties giving them important applications as wrought alloys in the aerospace industry and in military applications. On the other hand more than 5ppm Li in an alloy can cause problems with casting, so it could be important to be able to identify these alloys in scrap.

The SPECTROTEST is a mobile metal analyzer using the principle of Optical Emission Spectrometry(OES). In this technique, the atoms in the sample are excited not by X-rays but by an electric arc or spark, when each element emits light of characteristic wavelengths in the ultra-violet and visible regions of the spectrum. The arc or spark is generated at a sample probe on a flexible umbilical cord that can be up to 8m long. Like the xSORT the probe is simply placed in contact with the sample to take a measurement. Because metal atoms are expelled from the surface when the measurement is taken a small burn mark will occur on the surface of the sample. Light emitted by the sample is transferred via a fiber optic to the optical system where it is separated into its different wavelengths using a diffraction grating, and the individual intensities are measured with a suitable detector.

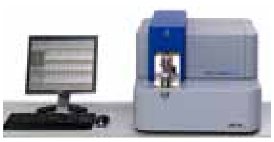
The SPECTROTEST detector is state-of-the-art: highly sensitive and fast multiple CCD's give fast analysis and generate high quality data that enables the same sophisticated approach to data handling as in the xSORT. Like xSORT, the SPECTROTEST uses ICAL procedures and can identify and verify alloys automatically in a few seconds. The physical constraints of the optical system mean that SPECTROTEST is larger than xSORT, weighing 64 lbs (29Kg), and less portable, although the sample probe can be up to 8m long and allows flexible sample access.

The SPECTROTEST can not only detect all the elements of interest in routine scrap sorting, but it can also detect elements like Be or Li that cannot be detected by hand-held XRF. The following results were obtained with a SPECTROTEST on samples of aluminum alloys that had been prepared by surface grinding. Each value is the average of three separate readings.

Typical example of results achievable:

4015 Alloy			
Ele-ment	**Certified Value [%]**	**Measured Value [%]**	**Standard Deviation [%]**
Si	1.82	1.86	0.0054
Fe	0.43	0.41	0.0130
Cu	0.196	0.18	0.0006
Mn	1.070	1.06	0.0120
Mg	0.450	0.43	0.0030
Zn	0.050	0.044	0.0018
Cr	0.043	0.038	0.0010
Ti	0.030	0.026	0.0023
Be	0.0038	0.0037	0.0001
Li	0.0006	0.0004	0.0001
Al	Balance	96.36	0.0290

Alloy type	**Certified Value for Li [%]**	**Measured Value [%]**	**Standard Deviation [%]**
1050	0.0021	0.0022	0.0001
1200	0.0015	0.0012	0.0001
6151	0.0007	0.0007	0.0001



Instruments for the Laboratory

When analytical results of the highest quality are required, the low detection limits, accuracy and speed of analysis achievable with SPECTRO's high performance OES analyzers such as the SPECTROMAXx and SPECTROLAB make them ideal for the QC or development laboratory. Full details of these instruments can be found on the SPECTRO website at www.spectro.com .

CONCLUSION

Elemental analysis of aluminum alloys can improve efficiency and add value at all stages of the aluminum recycling process. Portable and mobile spectrometers from SPECTRO Analytical Instruments are capable of accurate, rapid and reliable alloy identification, on site and in the hands of operators without specialized analytical knowledge.

www.spectro.com

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