

SORTING ALUMINUM PROFITABLY

Two approaches to sorting aluminum alloys with handheld X-ray guns are “basic” and “fine” sorting. The distinction is simple: basic sorting does not measure magnesium, silicon or aluminum, and fine sorting does. In the language of the scrap industry, basic sorting means sorting aluminums into 2000 series (or 2024 type due to high copper); 7050, 7075 or 7000 type (due to high copper and high zinc); and mixed low copper alloys (MLCs). Some X-ray guns attempt to identify specific aluminum alloys like 1100 and 3003 with basic sorting, but this is risky and often leads to downgrades and rejections (we explain why below).

Ten years ago, basic sorting was the only option with handheld analyzers. Today, however, with the advent of high-performance X-ray detectors and laser-based units, fine sorting aluminum alloys in a few seconds is a reality.

But why, when most guns on the market now have the option of both settings, have operators been sticking with basic sorting? The answer is simple. Historically, X-ray guns have been too slow for measuring Mg in particular. Many guns require 30 seconds or more to measure the 0.5% Mg in 6063. What sorter wants to stand around for 30+ seconds measuring a piece of aluminum? Especially when the lightness of aluminum means you need to sort a much higher volume for the sorting to be economically viable.

SciAps has stepped into the gap with XRF units designed to measure Mg and Si up to 10 times faster than other guns, so

Looking for Pure Value?

The older generation SciAps X-ray gun offers the same blazing speed and accuracy on aluminum and other alloys. While less sleek and slightly heavier at 3.25 lbs., the X-200 and X-250 will deliver **the same accuracy and throughput as the X-505 and X-550, at a lower price point.** And the older platform has been redesigned with better heat shielding and can operate continuously in ambient temperatures up to 115 F (46 C).



SciAps designed their XRF units to measure Mg and Si up to 10x faster than other guns so that operators could do fine sorting within a few seconds, rather than 30+ seconds.

that operators can do fine sorting within a few seconds. With improved throughput and accuracy, aluminum scrap sorting has been transformed.

Basic and fine sorting of aluminum alloys

The least expensive X-ray guns on the market

—those that use 30-year-old PiN diode detector technology incapable of measuring Mg, Si and Al —do basic sort-



ing. The SciAps X-50 analyzer is an example of this type of technology, and many users still rely on these types of guns because the price and performance meet their requirements.

PiN diode detectors limit sorting aluminum alloys to basic sorting. These X-ray guns measure only the heavier metals in the aluminum alloy, including titanium, vanadium, chromium, manganese, iron, nickel, Cu, Zinc, zirconium, lead, silver, bismuth, tin and other elements.

More modern X-ray guns—those that use silicon drift detectors (SDD)—additionally measure Mg, Si and Al. They can, therefore, do both basic or fine sorting, allowing users to ID grades easily and accurately. And yet, many users still choose to perform basic sorting using the instrument’s single beam mode instead of the dual beam mode that allows fine sorting because most SDD X-ray guns have been especially slow at measuring Mg, often taking up to a minute to measure 0.5% Mg in a 6063.



The SciAps engineering team has responded by designing SciAps XRF units to measure Mg and Si up to 10 times faster than other guns so that operators could do fine sorting within a few seconds. This technology now makes fine sorting economical and allows users to avoid the mix-ups common to basic sorting.

Basic sorting mix-ups, and why they occur

In today’s aluminum alloy market, basic sorting has several blind spots that can lead to expensive downgrades. This is especially true when operators attempt to be too specific on grade ID.

Basic sorting X-ray guns are only set up to measure the most likely series of aluminum or the most likely alloy within a series (2000 type or 2024, 3000 type or 3003, etc.). For instance, the operator might identify the alloy as 3003 instead of 3105, 3004 or 3005

SciAps Aluminum Alloy Sorting Guide

because the software in basic sorting is configured to identify an aluminum alloy with 1% or more of Mn as 3003. Another common mix-up is between 6063 and 1100. Most X-ray guns are configured that if you measure Cu between 0.05-0.2% and no other elements, then they ID the alloy as 1100. The problem is that 6063 has a Cu spec from 0-0.1% and requires Mg from 0.45-0.9%.

Operators using basic sorting can't measure the Mg, therefore, routinely misidentify 6063 as 1100—a frequent cause of anguishing downgrades.

In another example, if high Cu is measured but other elements like Zn, Mn, Cr are present in low concentrations or not at all, the X-ray gun will identify the alloy as a 2000 series, which is the traditional high-copper series. Some guns will call this alloy a 2024 because 2024 is the most likely 2000 series encountered in many recycling facilities. However, specifically calling an alloy 2024 can lead to mix-ups. Alloy 2014 has the same Cu specs as 2024, but much lower Mg. Since basic sorting doesn't measure Mg, it will not be able to distinguish these two alloys.

In a nutshell, the SciAps X-ray guns can be configured to provide fine aluminum alloy sorting at the speeds of basic sorting.

A more troubling problem, one we see all the time, is with cast aluminums. X-ray guns set for basic sorting can't measure Si but can measure Cu (often high) in cast aluminums. The result is a cast aluminum erroneously being called a 2000 series. [Note: SciAps XRF, in basic sorting mode, labels these alloys as "2000 series or cast," and in fact, experienced operators using basic sorting have learned to visually identify many cast alloys to avoid this mix-up.]

Modern SDD X-ray guns can avoid mix-ups of aluminum alloys by measuring Mg, Si and Al in their 2-beam setup. The XRF gun tests for a few seconds in the Beam 1 setting (basic sorting) to measure the heavier elements like Ti, V, Cr, Mn, Fe, Cu, Zn, Zr, Ag, Sn, etc. Then the gun changes to Beam 2, shifting the X-ray tube to a lower voltage and different X-ray filter to be optimal for measuring Mg, Si and Al (as well as phosphorus and sulfur, for other applications).

Where does laser (LIBS) fit in?

LIBS devices have been in use in scrap sorting for several years now. In fact, SciAps makes the best-selling LIBS system. We see LIBS as a niche product in the scrap recycling industry, ideal for several applications not capable with X-ray. These include:

Faster, more precise Mg measurements than XRF

Our XRF is the fastest unit on the market measuring Mg in aluminum alloys. Still, it requires 2-3 seconds to measure 0.35 Mg, and that's at a precision of about +/- 0.05% Mg. However, if you want to measure Mg to levels < 0.25% faster, and also with better precision in general, then LIBS is the better tool.

Directly measuring Li in aluminum alloys

Lithium is increasingly common in aerospace aluminum—and a big problem if it's mixed in with other Al scrap. X-ray cannot measure Li directly; the atomic number is too low. But LIBS is very sensitive to Li and can measure it down to a few ppm concentration in aluminum alloys. It's worth noting that some operators do identify Li-containing aluminum indirectly with X-ray. When lithium is added to aluminum alloys, it is added as a Li-Ag (silver) complex to improve homogeneity. X-ray is very sensitive to Ag, therefore, X-ray may be used to measure Ag as a

pathfinder element. If you measure Ag with your X-ray, it is very likely that Li is present.

Boron and beryllium

X-ray also cannot measure boron and beryllium because the atomic numbers are too low, so LIBS is used often to measure both B and Be as contaminants in aluminum alloys. The limit of detection is 1-2 ppm for Be and 10 ppm for B. LIBS also measures Be in other alloys, most notably beryllium-copper alloys, boron-containing nickel alloys, plus boron in duplex steels used in the nuclear power industry.

Carbon in steels and stainless

The SciAps LIBS will also measure carbon in your ferrous, stainless and nickel alloys. If there is value in sorting steels by carbon content or sorting stainless by L-grades and H-grades, the SciAps Z will accomplish these tasks.

No ionizing radiation

If you're just tired of dealing with X-ray gun registration, inspections, wearing dose badges and recordkeeping, then our LIBS unit, which operates under Class 1 conditions, is a great alternative. As we tell all users, the LIBS will deliver excellent results on aluminum alloys, titanium and ferrous. However, it will not be as precise on stainless and high temps as X-ray nor be as easy for turnings. LIBS will ID the high-temp alloys



correctly, but the precision of measurement of Ni, Co, Mo, Nb, Ta, W and other refractory elements will not be as good as X-ray. These refractory elements are the "sweet spot" of X-ray.

Anodized aluminum

If you deal with a lot of anodized material, the SciAps LIBS will burn through the anodized surface, eliminating the need to grind. Grinding the anodization off the surface is essential for good X-ray results. LIBS also burns through surface dirt. For X-ray, the surface dirt must be wiped away otherwise high Si results lead to mix-ups of wrought 5005 and 6022, for example, or cast aluminums.

REFERENCE GUIDE FOR ALUMINUM ALLOY SORTING

	Models	Pros	Cons
<p>BASIC</p> <p>Sorting into most likely grade type, for example: 2024 type, 7050, 7075 type, 3003 type, mixed low coppers (MLCs).</p>	<ul style="list-style-type: none"> • PiN or SDD type guns. • For SDD X-ray guns, only applies to 1-beam testing. • Most models will do this level of sorting in 1-2 seconds (SDD) or 3-4 sec (PiNs). 	<ul style="list-style-type: none"> • Fast, easy for basic Al sorting. • Even least expensive X-ray guns can do this level of sorting. • Minimal operator decision making. • Anodized material generally has no impact on sorting result since no Mg or Si measurement. • If your economics only require a basic level of sorting, this approach may be enough. 	<ul style="list-style-type: none"> • No measurement of Si or Mg so cannot reliably separate into more specific grades. • Attempting too-fine sorting of grade IDs can lead to mix-ups and downgrades. Common examples include the following, but there are more: 6063/1100 mixes;¹ 3105, 3004, 3005 identified as 3003;² calls every 5000 a 5052 based on low Cr content;³ cannot separate high Mg 5000s like 5083, 5086; IDs 2014 and similar 2000s as 2024 type;⁴ and also mixes with cast grades;⁵ can mix some low-Mg 5000s (like 5005) with 6000s (like 6022) since no Si measurement.⁵
<p>FINE SORTING</p> <p>Measure Mg and Si, allowing for finer sorting by aluminum grade.</p>	<ul style="list-style-type: none"> • Only SDD type X-ray guns. • Performance Metric: Sorting on low Mg content (6063, 6061, etc.), measure 0.5% Mg in aluminum. • SciAps X-250 measures Mg in 2 seconds. • SciAps X-200 sorts in 5 seconds. • All other X-ray gun brands require 15-60 seconds. 	<ul style="list-style-type: none"> • Easily sort grades that only differ by low levels of Mg or Si, if this makes sense economically. • Eliminate 6063/1100 mix-ups forever. • Sort within 2000s, for example 2014 from 2024. • Sort within 3000s: 3003/3105/3004/3005. • Sort cast aluminums by Si content, and those that differ by Mg like A356, A357 (0.3-0.5% Mg vs 0.5-0.7%). • Separate within 6000 series like 6061, 6022. • Separate various 5000 grades by Mg such as 5052, 5083, 5086, 5005, etc. 	<ul style="list-style-type: none"> • XRF guns with fine sorting capability are more expensive. Users must determine if faster, more accurate sorting is worth the additional cost. • Somewhat higher level of operator training and aluminum alloy knowledge is preferred but not required. • Operator may have to grind or wipe material sometimes, since surface dirt often contains Si. • Anodized aluminum requires grinding to measure Mg and Si.

Why certain mix-ups occur

Does this happen with your X-ray gun? Frequent mix-ups between certain alloy grades? We explain them below.

¹ **6063, 1100 mix-ups:** All the “basic sorting” analyzers use copper as a basis for sorting 1100 from 6063. 1100 has Cu specified as 0.05-0.20%. 6063 has a spec of 0.1% max. If copper is greater than 0.1%, the X-ray calls the material 1100. Here’s the problem: Intrinsic Cu content in 6063 has steadily increased to 0.1% and sometimes higher. The accuracy of the basic X-ray guns often means a true copper reading of 0.08 or 0.09% reads 0.1% or higher, making the gun ID the material incorrectly as 1100. The “advanced” gun measures Mg. 6063 has Mg between 0.45-0.9%; 1100 has none. Thus, the only definitive way to sort 1100 from 6063 is to measure Mg. The SciAps X-250 measures the Mg in 6063 in 2 seconds. Other X-ray guns require 30 seconds or more, making it impractical economically. Never mix your 6063/1100 again.

² **3000-series mix-ups:** “Basic sorting” X-ray guns are trained to classify aluminum alloys with 1% or more Mn as 3003 type because 3003 (Mn spec 1-1.5%) is the most likely alloy with this Mn content. However, the material could be 3004, 3005 or possibly 3105. A

Mg measurement is required. 3003 has no Mg. 3004 has the same Mn as 3003, but 0.8-1.3 Mg. 3005 has same Mn as 3003, but 0.2-0.8 Mg. 3105 has Mn spec 0.3-0.8, so 3105 on the high end of the Mn spec can be erroneously classified as a 3003 without the Mg measurement.

³ **5000 series mixes:** Most X-ray guns doing basic sorting assume if Cr is detected in the 0.2% range, and Cu, Zn and Mn are all < 0.5%, then the alloy is 5052 type. Sometimes 6061 is classified as 5052 type if the Cu is on the low end of the 6061 spec, closer to 0.15%. The basic sorting method also mixes a variety of 5000s and 6000s like 5005 and 6022 because this method does not measure Si. Finally, since there is no Mg measurement, high Mg 5000s like 5083 and 5086 will be identified as 5052 type. Fine sorting eliminates these mixes because it measures Si and Mg.

⁴ **2024, 2014 mixes:** Basic sorting can’t measure Mg, which is the only difference between 2024 and 2014. This is true of other 2000s and 7000s as well. The SciAps

fine sorting separates these in 2 seconds and eliminates these mix-ups.

⁵ **Cast, 2000s, other low copper Al alloys:** Basic sorting keys on low or high Cu, low Cr or 1% Mn, and then assumes the alloy is a specific type like 1100, 6061, 2024, 5052 or 3003. However, many aluminum alloys have low Cu, Cr or Mn, which is why this approach leads to mix-ups. Cast aluminum with high Cu will be identified as a 2024 type when there is no silicon measurement. The SciAps Aluminum App measures Mg and Si as fast as the transition metals, allowing fast reliable sorting of many grades.

For more information, or to schedule a demonstration:

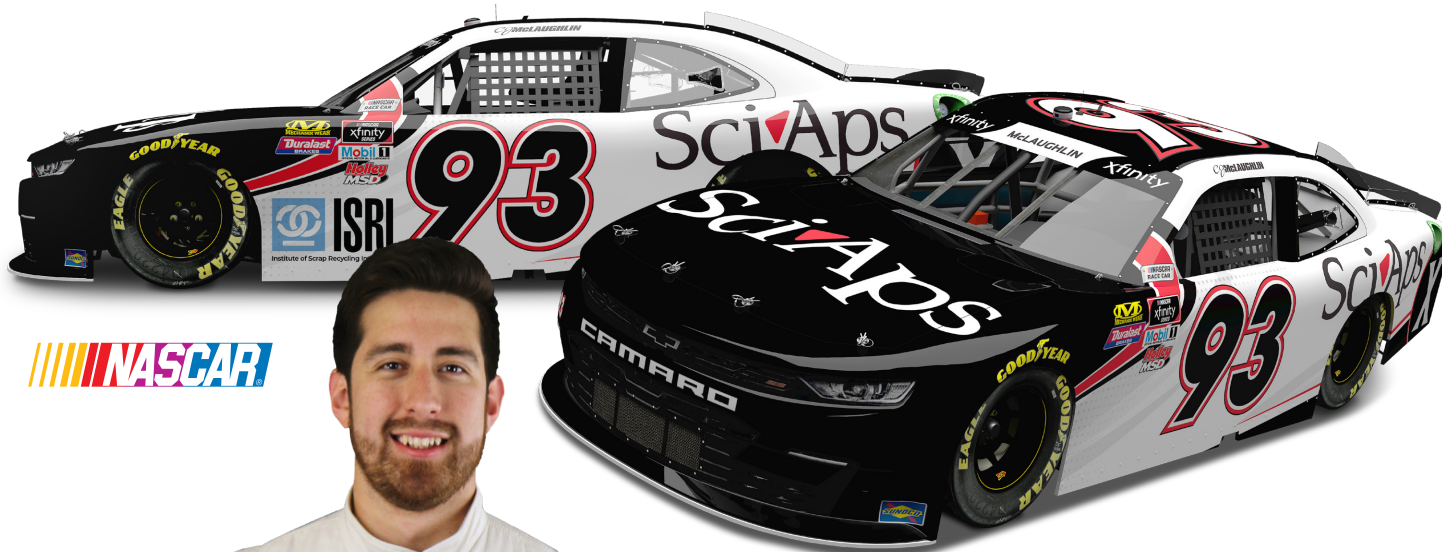
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