



Electronic Scrap Analysis

Review of ISO 17025 Method for the Analysis of Electronic Scrap

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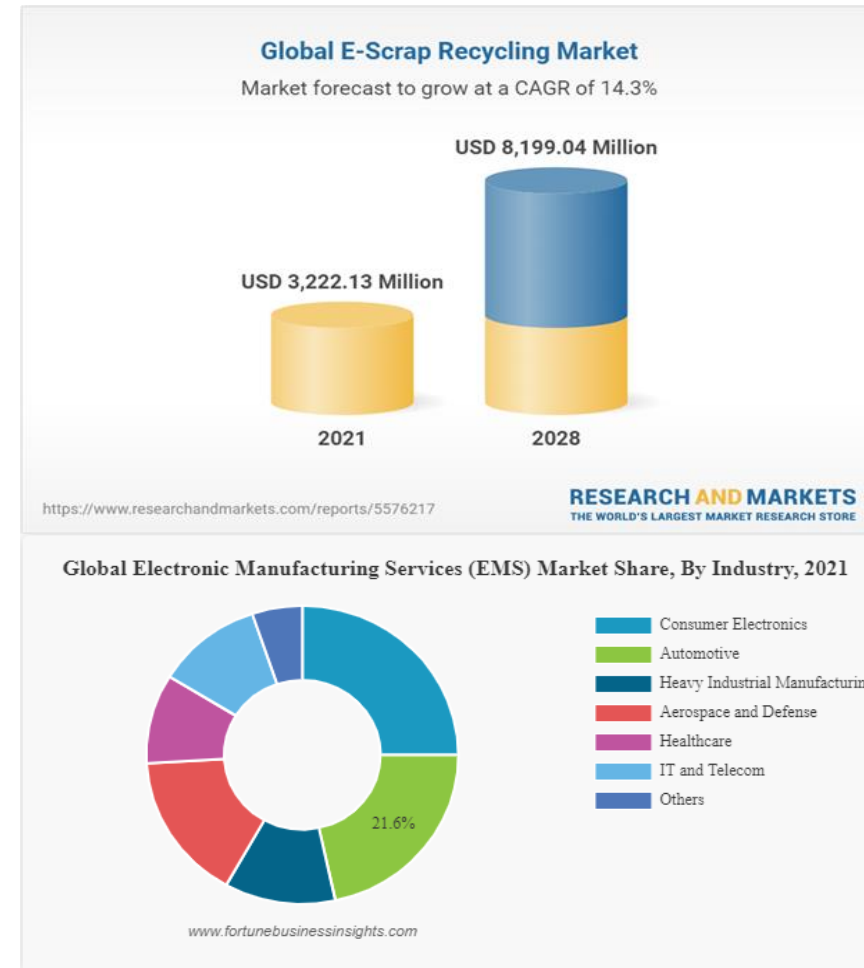
Future of Electronic Scrap Recycling

- 🔥 E-Scrap contains precious metals such as Silver, Gold, Palladium, Platinum, Indium, and Gallium which need to be recycled for the use in new electronic devices.
- 🔥 In 2019 the world dumped 53.6 million metric tons of E-waste out of which only 17.4% was recycled. 44.3 MMT went to landfills
- 🔥 E-Scrap recycling market is on the rise due to companies moving towards low-carbon footprint and emphasis on environmental responsibility
- 🔥 Climate change, sustainability, ESG footprint important to consumers



Future of Electronic Scrap Recycling

- 🔥 E-Scrap recycling market is expected to reach \$8.2 billion by 2028
- 🔥 Registering a CAGR (Compound Annual Growth Rate) of 14.3% from 2021 to 2028
- 🔥 Global electronic manufacturing \$504.22 billion in 2022 to \$797.94 billion by 2029



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Ledoux & Co. ISO 17025 Accredited

- 🔥 Since 1880, Ledoux & Co. has provided assay & consulting services with Accuracy and Quality as its core principles
- 🔥 Method for E-scrap analysis was ISO 17025 accredited in 2020
- 🔥 Assay results are commercial grade and used for control and exchange/umpire



CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Ledoux & Company
359 Alfred Avenue
Teaneck, NJ 07666

Fulfills the requirements of

ISO/IEC 17025:2017

In the field of

TESTING

This certificate is valid only when accompanied by a current scope of accreditation document.
The current scope of accreditation can be verified at www.anab.org

R. Douglas Leonard Jr., VP, PILR SBU
Expiry Date: 29 July 2024
Certificate Number: L2426



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017.
This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory
quality management system (refer to joint ISO-ILAC-IAF Communique dated April 2017).

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Ledoux & Co. ISO 17025 Audit

🔥 ISO 17025 Audits for our ISO methods are conducted annually, and our methods, results, standards, equipment, QC, and protocols are extensively evaluated

🔥 Traceability, documentation, and adhering to the strict protocols are essential for ISO 17025 accreditation



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

Ledoux & Company
359 Alfred Avenue
Teaneck, NJ 07666
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bnpeterson@ledoux.com

TESTING

Valid to: July 29, 2024

Certificate Number: L2426

Specific Tests and/or Properties Measured	Specification, Standard, Method, or Test Technique	Items, Materials or Product Tested	Key Equipment or Technology
Determination of Pd, Pt, Rh by ICP w/ Tellurium Collection	L0012/ L0085	Auto Catalysts, Petrochemical Catalysts, and Shurries	Co-Precipitation / ICP Pd: 0.001-10 % Pt: 0.001-10 % Rh: 0.001-10 %
Determination of Palladium	L0057	Palladium Nitrate Solution	Gravimetric / ICP Pd > 5%
Determination of Platinum	L0056	Platinum 'A' Solution	Gravimetric / ICP Pt > 5%
Determination of Rhodium	L0058	Rhodium Nitrate Solution	Gravimetric / ICP Rh > 5%
Loss on Ignition	L0013	Auto Catalysts, and Petrochemical Catalysts	Gravimetric 0.05-100 % Ignition loss
Fire Assay	ASTM E1335	Gold Alloys	Fire Assay 0.5-4%; 20.0-99.0%; 98.9-99.8%
Determination of Silver, Gold, Palladium and Platinum	L0003/ L0085	Electronic Scrap	Fire Assay / ICP Ag 10 - 5000 g/mT Au 2 - 2000 g/mT Pd 2 - 2000 g/mT Pt 2 - 2000 g/mT

Version 005 Issued: July 8, 2021

www.anab.org



Page 1 of 2

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Quality Control Standard BAM-M505a

🔥 Ledoux & Co. participated in the Round Robin Proficiency Test for BAM-M505a certified reference material (Electronic Scrap)

🔥 BAM-M505a is used as a QC standard for all E-Scrap Analysis

🔥 Currently researching to find standard reference material in metal form

Certified Reference Material

BAM-M505a
Electronic Scrap

Certified Values

Element	Mass fraction ¹⁾ in %	Uncertainty ²⁾ in %
Cu	16.76	0.04
Ni	0.694	0.006
Ag	0.0633	0.0009
Pb	1.13	0.05
Cr	0.980	0.017
Sn	0.469	0.016
	in mg/kg	in mg/kg
Au	52.4	0.9
Pd	48.0	0.8
Pt	5.7	0.4
As	372	20
Be	7.1	1.0
Cd	16.4	0.8

¹⁾ Unweighted mean value of the means of accepted sets of data (consisting of at least 2 but usually 6 single results), each set being obtained by a different laboratory and/or a different method of measurement.

²⁾ Estimated expanded uncertainty U with a coverage factor of $k = 2$, corresponding to a level of confidence of approx. 95 %, as defined in the Guide to the Expression of Uncertainty in Measurement, (GUM, ISO/IEC Guide 98-3:2008).

This certificate is valid until 06/2049.

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Ledoux & Co results BAM-M505a RR

 Ag

Ag	Ledoux & Co		Certified Value
M_i [%]	0.0629		n
	0.0639		13
	0.0624		
	0.0635		
	0.0641		
	0.0637		
M(B1)	0.0631		
M(B2)	0.0638		
M [%]	0.0634		0.0633
s [%]	0.0006	s_M [%]	0.0014
		\bar{s}_i [%]	0.0008
S_{rel}	0.01019		0.02166

 Au

Au	Ledoux & Co		Certified Value
M_i [mg/kg]	53.5		n
	53.7		12
	51.7		
	54.9		
	53.4		
	53.7		
M(B1)	52.967		
M(B2)	54.000		
M [mg/kg]	53.48		52.42
s [mg/kg]	1.028	s_M [mg/kg]	0.0014
		\bar{s}_i [mg/kg]	0.0008
S_{rel}	0.019		0.02166

 Pd

Pd	Ledoux & Co		Certified Value
M_i [mg/kg]	47.1		n
	47.7		12
	48.1		
	47.3		
	47.8		
	47.5		
M(B1)	47.643		
M(B2)	47.513		
M [mg/kg]	47.58		47.98
s [mg/kg]	0.360	s_M [mg/kg]	1.253
		\bar{s}_i [mg/kg]	0.732
S_{rel}	0.008		0.026

 Pt

Pt	Ledoux & Co		Certified Value
M_i [mg/kg]	6.5		n
	6.1		12
	7.1		
	6.4		
	5.8		
	6.8		
M(B1)	6.567		
M(B2)	6.333		
M [mg/kg]	6.45		5.73
s [mg/kg]	0.468	s_M [mg/kg]	0.546
		\bar{s}_i [mg/kg]	0.493
S_{rel}	0.073		0.095

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Sample Preparation of E-Scrap

- 🔥 It is essential that a representative sample portion is taken for accurate assay results with good agreement between the replicates
- 🔥 All E-scrap samples in powder/fines form are rotary split before analysis (Quantachrome)
- 🔥 All E-scrap metals in shot form are also split and randomly selected and weighed to get the best representation of the sample



Method Summary

🔥 Method is applicable in the range:

🔥 Ag 10 - 5000 g/mT

🔥 Au 2 - 2000 g/mT

🔥 Pd 2 - 2000 g/mT

🔥 Pt 2 - 2000 g/mT

🔥 Gold, Palladium, and Platinum are separated by fire assay using Silver as a collector. Silver is removed by de-nitration. Residual precious metals are dissolved in aqua regia. Gold, Palladium, and Platinum are quantified by ICP-OES.



Method Summary (continued)

- 🔥 Silver in low-grade samples are separated using Gold or Palladium as a collector. If Silver contents of the sample are significant, addition of a collector may not be necessary and a Total Precious Metal (TPM) bead is used to determine Silver. TPM is dissolved and Silver is determined by ICP-OES.
- 🔥 Metallic samples and pyrite powders may be dissolved in acids and analyzed by ICP-OES directly.
- 🔥 Matrix matching, calibration standardization, internal standards, and drift correction techniques must be used for high precision & accuracy. A QC standard (BAM M505a) is run with every batch.





Ledoux & Co. Vision Moving Forward

- 🔥 The automotive industry accounts for over 21% of the total Global Electronic Manufacturing . EV vehicles are on the rise and companies like Ford are aiming for an all EV line-up by 2035.
- 🔥 Battery recycling will be essential to accommodate the demand for EV vehicles. Once a battery reaches the end of its life, it is dismantled, and shredded and processed into a “black mass”. The black mass contains large quantities of the main metals (Ni, Co, Mn, Li, Al, Cu, Fe) used in production of cathode materials (CAM). Li, Ni, Co, and Mn can then be extracted from the black mass and reused in new battery production. The black mass will be the feedstock for the commercial hydrometallurgical refinery for battery recycling.

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Ledoux & Co. Vision Moving Forward

- 🔥 Battery recycling is an important lever to reduce the carbon footprint of battery-powered electric vehicles and key to meeting the global demand for sustainability.
- 🔥 Ledoux & Co. is working with companies on the forefront of battery recycling and excited to collaborate on analytical processes to help determine key elements in the refining/recycling recovery process.

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Thank You!

Questions?

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