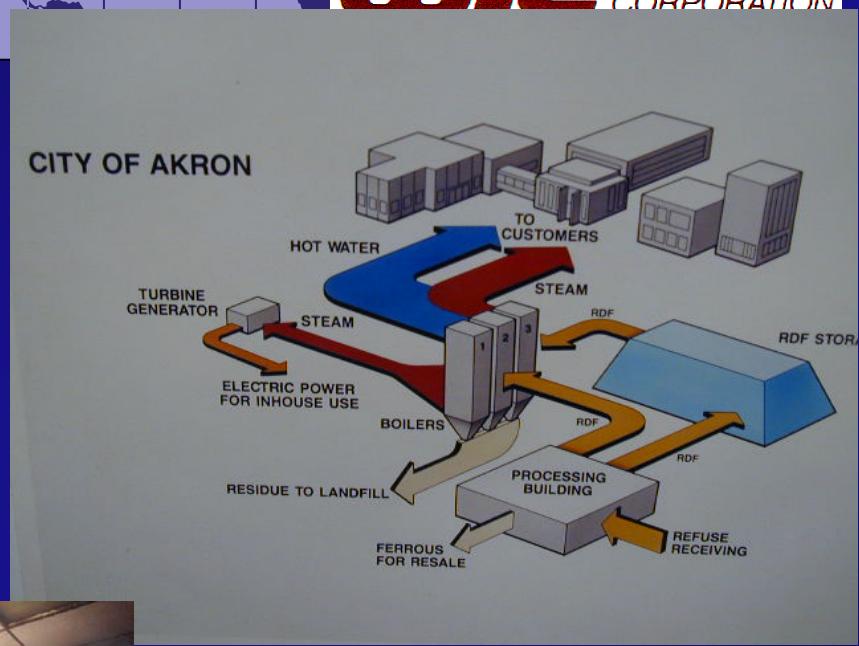


Government-University-Industry Research Roundtable

**Diminishing Natural Resources:
Recognizing Limitations,
Responding to the Challenges**

**Advanced Optoelectronic Technologies for
Recycling Strategic Materials**

*David B. Spencer, Sc.D.
wTe Corporation*



Early wTe History: Akron Recycle Energy System

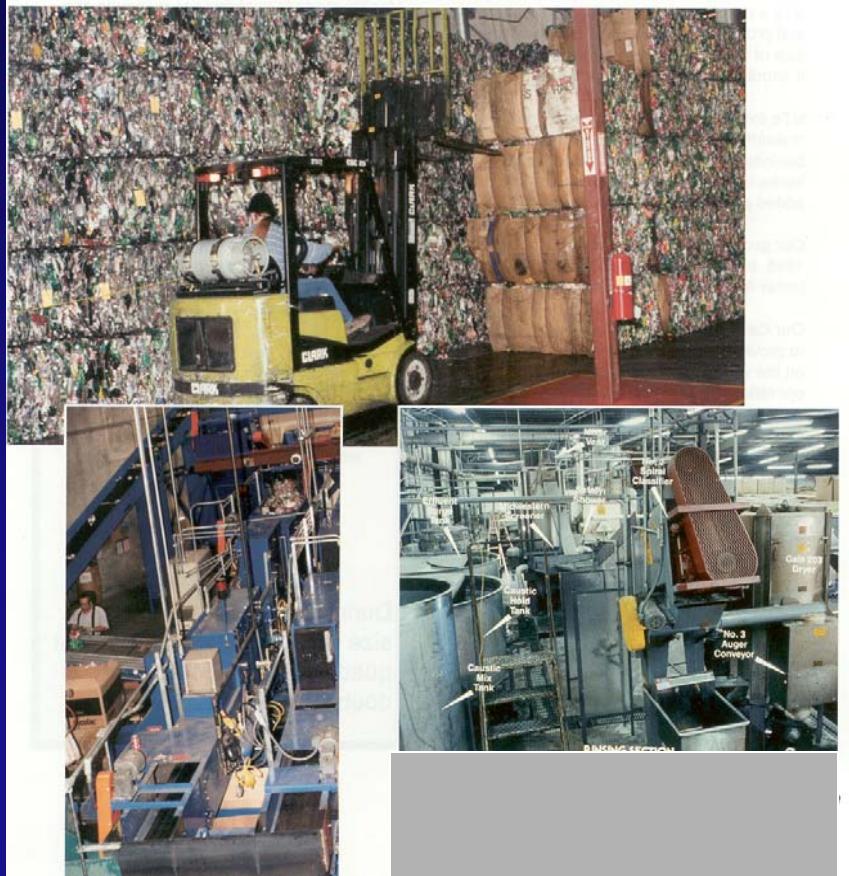




Spec^{tr}amet[®] LLC



wTe's Plastics Recycling & Reclaiming Business



State of the Art High Speed
Optoelectronic Bottle Sorting

High Capacity Grinding

Sophisticated Chemical
Cleaning & Washing

Pelletizing Recycled Resins



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FDA Bottles to Bottles Requires Extreme Purity



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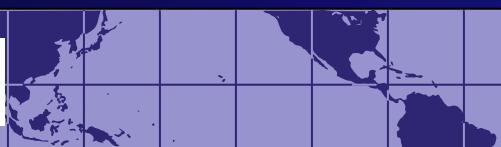
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wTe's Ferrous Metals Processing Business





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Processed Auto & RDF Ferrous





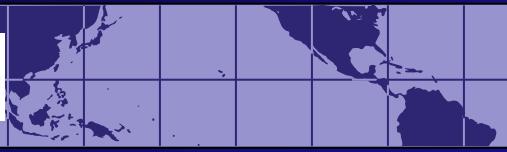
*New
Orleans,
Bourbon
Street, 21st
Century.*

*What will
remain after
500 years?*





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Economic Wealth vs. Waste Generation

- **ALL** of our manufactured goods, buildings and all biological plants and animals (including our own bodies) will eventually become the waste of tomorrow.
- Tomorrow's waste is Today's GNP.
- The more we earn, the more we buy.
- "Save the Planet, Kill Yourself."



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The Scope of the Problem:

- 1960. US. 87.8 million tons of waste.
- 2000. US. 217.8 million tons of waste (4.5#/day).
- 2006. US. 51.4 million tons of plastics produced.
- 2002. Worldwide. 1 billion tons of iron ore.
- 50 million vehicles junked annually; 15 million in the US alone.
 - 75% Metal
 - 7% Plastic
- Growth is mixed for U.S., but not globally.



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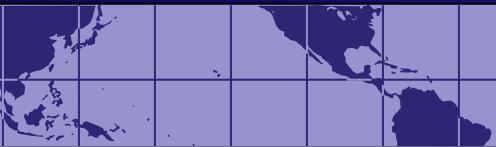


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Our Waste is a Positive Consequence of Our Wealth and Success

- Packaging protects the product inside.
- Packaging provides for consumer safety and information
- Packaging provides access & convenience to the consumer.
- Would you want to buy a TV-Stereo packaged in a brown paper bag, scraped and dented during shipping?
- Would you want to buy drugs without a seal and without the information on the package regarding dose, risks etc.
- Why do we pay \$1.00 for bottled water? Isn't the package critical so you can quench your thirst while jogging or walking.



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When does the waste problem become a recycling opportunity?

When the *economic value* from recycling waste and scraps can compete economically with manufacture of new products from virgin feedstocks then and only then will recycling flourish as a business.



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How Recycling Was Done in the Good Old Days



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The Ragpicking Business



- **The variety of items recuperated** and their recycling testified to the rag picker's ingenuity. **No less than 400 different types of** woolen, silk, cotton and canvas rags were bought by industry for various purposes. Empty bottles, broken glass, corks, straps, old paper and boxes, metal extracted from buttons or picture frames, shoes, crusts of bread, orange peel, bones or even small locks of hair – all were reworked, remodeled and resold in various forms.



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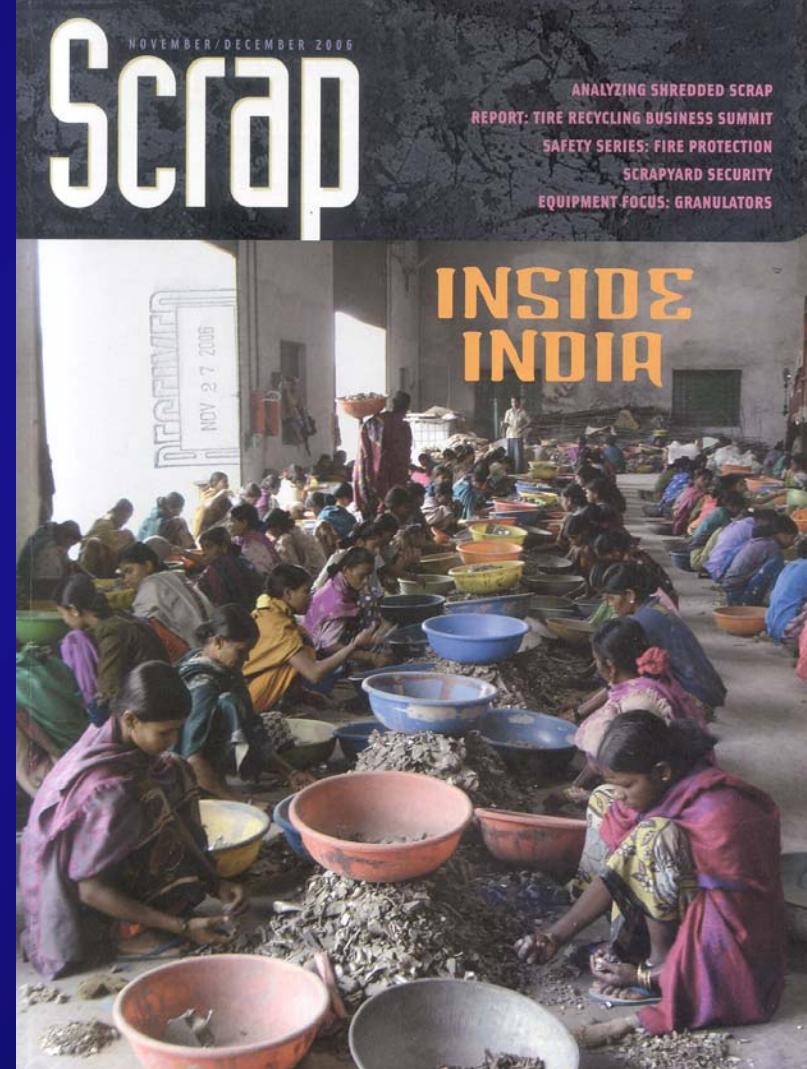
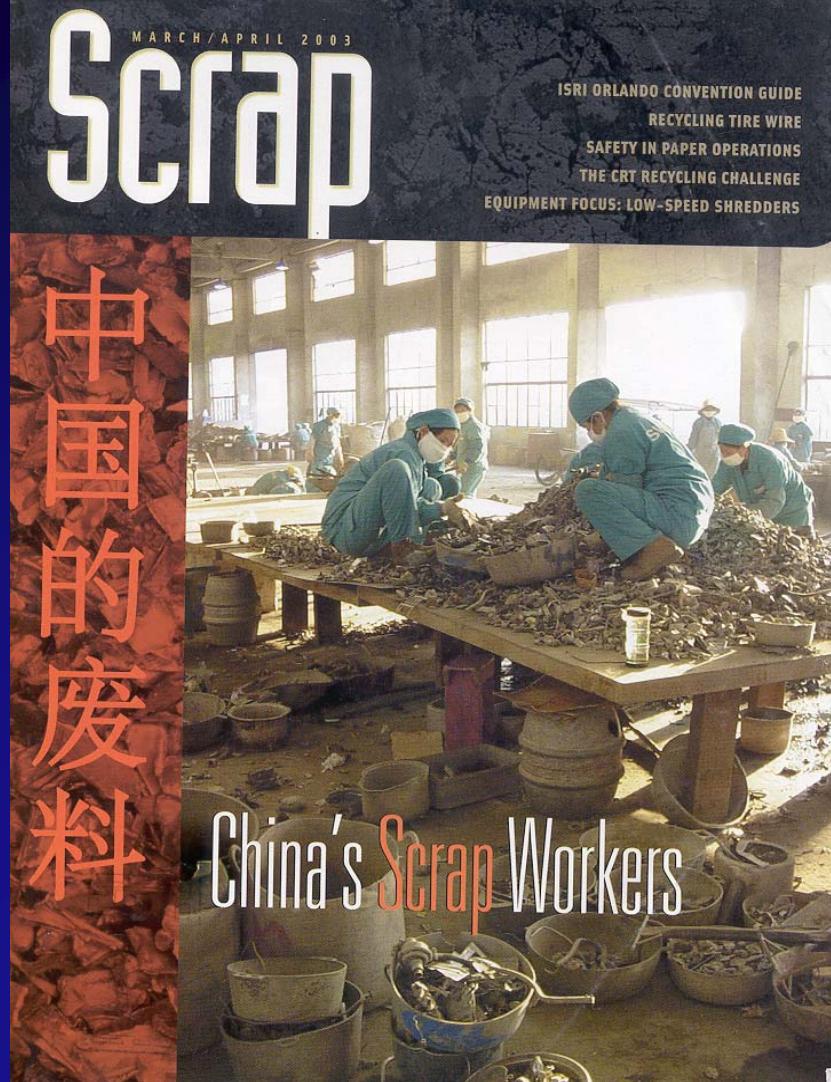
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How Recycling is Done Today in the 21st Century



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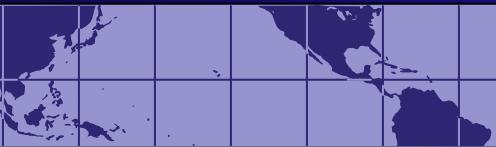
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China's Full Scale Sortation Factory





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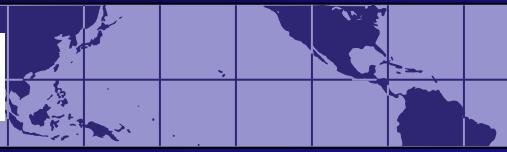
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How Can the U.S. Compete?

- Pay our workers less than China does
- Raise China's Labor Rates
- Send our business to China
- Get into another business
- All of the above
- None of the above
- *Make a cheap device that replaces people*
- *Make a device that does a better job*



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Alternative Processing Approaches

- Minerals Beneficiation Techniques: Mass Migration
 - Magnetic Separation
 - Screening
 - Air Classification
 - Eddy Current Separation
 - Froth Flotation
 - Heavy Media Separation
 - Friction
- Optoelectronic Techniques: Particle by Particle
 - Color Sorting
 - LIBS
 - X-rays (DXRT and XRF)



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The Challenge

What cannot be done today, but if it could be done, would revolutionize the way business is done.

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BOTTLE SORT[®] CORPORATION





Speotramet[®] LLC



FLAKESORT

FLAKESORT[®] CORPORATION



NRT

**Four
Module
FlakeSort
System
Installed in
Plastics
Recycling
Plant in
Venice,
Italy**



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New Spectramet Technology Concept

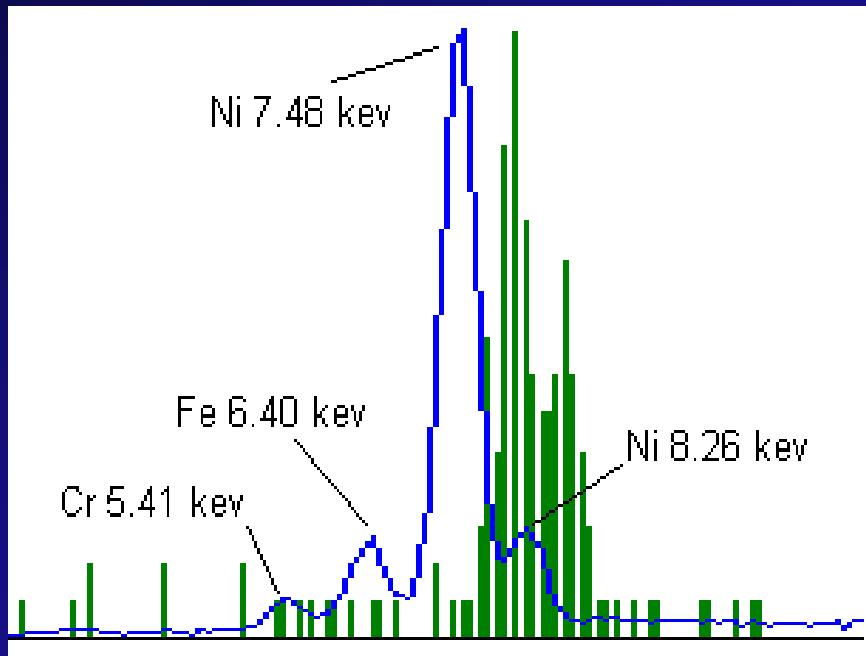
- Do the same sort of optoelectronic sortation on metals that we do on plastics
- Focus on metals because much more of it and more lucrative
- Needed a technology for metals and ability to sort many more types of material unambiguously at high speed



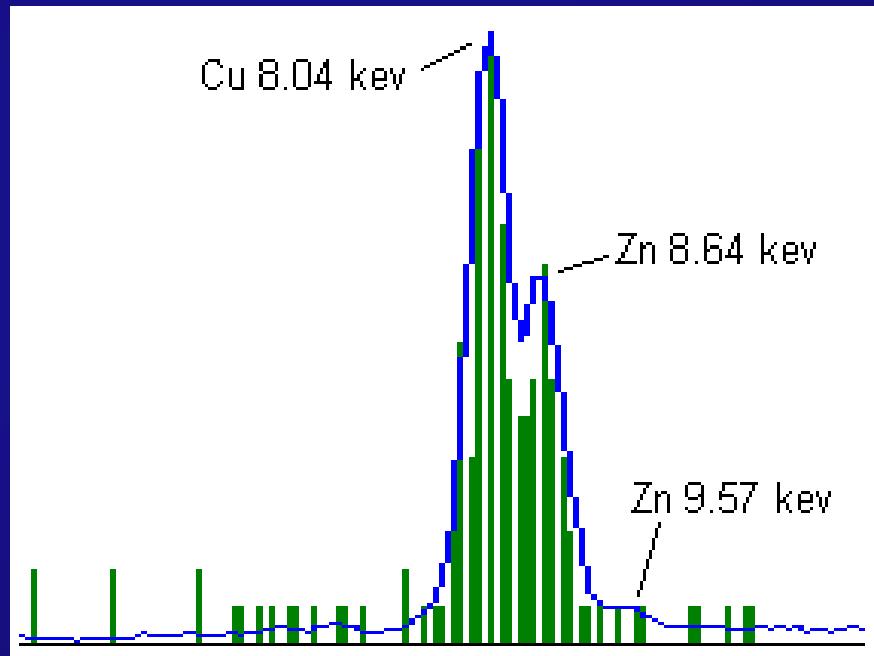
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How It Works



data: Brass08 50ms sample time
ref: ChromePlate *dot product = 0.292*



data: Brass08 50ms sample time
ref: Brass360 *dot product = 0.961*

Courtesy of *National Recovery Technologies, Inc.*



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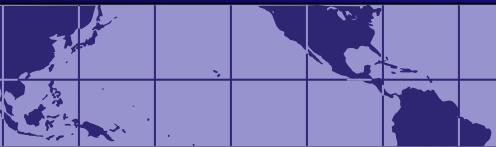
Obtained Federal Funding to Fund R&D and Reduce Business Risk

- Multiple funding grants from National Science Foundation
- Multiple Awards from NIST ATP Program/Department of Commerce





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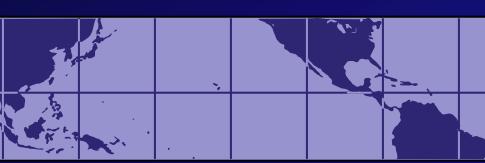
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Government-University-Industry Collaboration

- Formed World Class Strategic Advisory Board
- Optoelectronics Expertise from NIST and NRT
- Academic Leaders from MIT in Metallurgy and Vanderbilt in Physics
- Executives from Each Major Industry Group: Aluminum, Stainless, Copper, Brass, Precious Metals
- Venture Capitalist & NIST-ATP Business Mentors
- Substantial Government Funding from NSF and NIST



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Strategic Advisory Board





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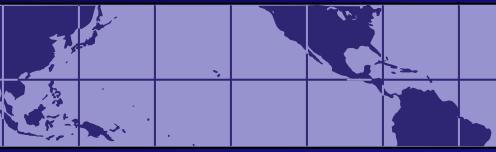
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Other Sources of Metal

- Automobile Shredder Metals
- Post Consumer Metals
 - Deposit
 - Curbside
 - RDF Waste To Energy
 - Mass Burn Waste To Energy
 - Nonferrous Metals
- Commercial Scrap



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Nonferrous Metal Concentrates after shredding, air classification and magnetic separation.





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Eddy Current Separation





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Zorba





Semi Commercial DXRT Replaces Heavy Media Plant.

Next Steps:

1. Twitch to be Grouped into cast, wrought, or by alloy.
2. Zebra to be Grouped into Zinc, Copper, Brass Bronze and Stainless.

Differential X-Ray Transmission (DXRT) Process Diagram

ZORBA (Feed to DXRT)

Auto-shredder Non-Ferrous Metal Concentrates (NFC)
after Eddy Current Sortation



DXRT



ZEBRA
(Heavy Non-Ferrous Product:
Mostly Cu, Zn, Stainless, etc.)



TWITCH
(Light Non-Ferrous Product:
Mostly Aluminum)



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TWITCH





Reducing greenhouse gas emissions.

- In the case of aluminum:
 - Recycling aluminum results in 95% less air pollution and 97% less water pollution than producing primary or virgin aluminum from ore.
 - Recycling aluminum saves 95% of the energy necessary to mine bauxite ore, extract alumina, the raw materials needed to manufacture aluminum and produce metal from it.
 - Recycling 1 ton of aluminum saves the equivalent in energy of 2350 gallons of gasoline. This is equivalent to the amount of fuel needed to provide a typical home with electricity for a period of 10 years.



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Recycling Advantages

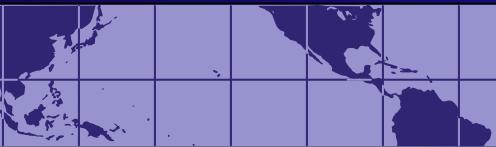
- Recycling iron and steel saves 74% of energy and 86% of emissions compared with primary production

Other Energy savings are:

- 95% for aluminum
- 85% for copper
- 65% for lead
- 60% for zinc
- Over 80% for plastics.



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Aluminum and Other Nonferrous Metals. Market is Growing!

- Demand for aluminum and nonferrous metals is increasing, not decreasing.
- Escalation of energy costs increases the demand for recycled aluminum as compared to virgin raw materials (13 to 1 energy ratio).
- Automobile light weighting and CAFÉ standards create a bias to aluminum from steel.
- Global demand is increasing dramatically for all nonferrous metals both in absolute terms and as a percentage of demand for all materials.



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ZEBRA





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Alloy Grouper Business Opportunity



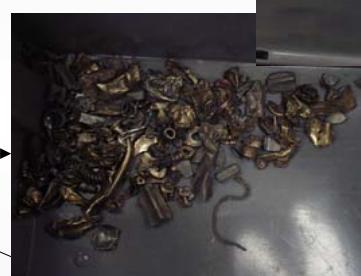
Mixed NFC from Auto Shredder



GROUPER



Stainless



Zinc



Brass



Copper



Chrome-Plated Zinc

*Alloy Grouper accepts
DXRT Heavies after
Aluminum Removal and
Groups into Copper, Brass,
Bronze, Zinc, Stainless, etc.*



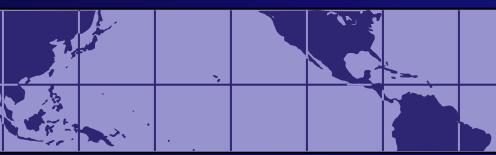
Aluminum and Other Unidentified Metals

Commercial Alloy Sorter





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Aerospace Metals and Superalloys





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Platform of Spectramet Technologies

- **Alloy Grouper** Original NSF Separator. Sortation of small solids into groups (copper, brass, aluminum, zinc, stainless steel). High speed
- **AlloySort™** Exact alloy sortation of solids. Applicable to high value materials, such as titanium and Superalloys. 100% accuracy required. Commercial now
- **Differential X-ray Transmission (DXRT)** Mass flow of solids, high speed, applicable to non-ferrous concentrates from shredder. Commercial pilot scale now
- **ChipSort™ Technology** Applicable to contaminant removal from machining chips, fasteners, very small solids



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Potential Alloy Groups

- Nickel Base, Cobalt Base & Stainless Steel Alloys
- Copper, Brass and Bronze Alloys
- Aluminum Alloys
- Titanium Alloys
- Precious Metal Alloys
- Other Alloys (Zinc, Lead, Tin, Others)



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Commercial Challenges:

1. Gain Acceptance for Feedstocks
2. Generate Specifications New to the Industry
3. Commitment for Trial Tests at Major Facilities.
4. Establish User Needs and Melt Shop Requirements
5. Evaluate Alternative Feedstock Supply Sources
6. Logistics for Handling Production Volumes



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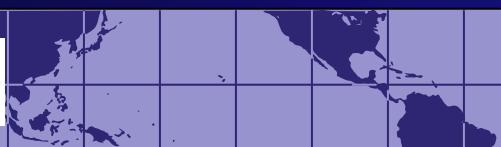
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Business Challenges:

- Quantifying Environmental Benefits to Users
- Measuring Compositional Variations
- Evaluating Consistency among Production Lots
- Getting the Best Price for Products
- Quantifying Economic Benefits (e.g. profit)



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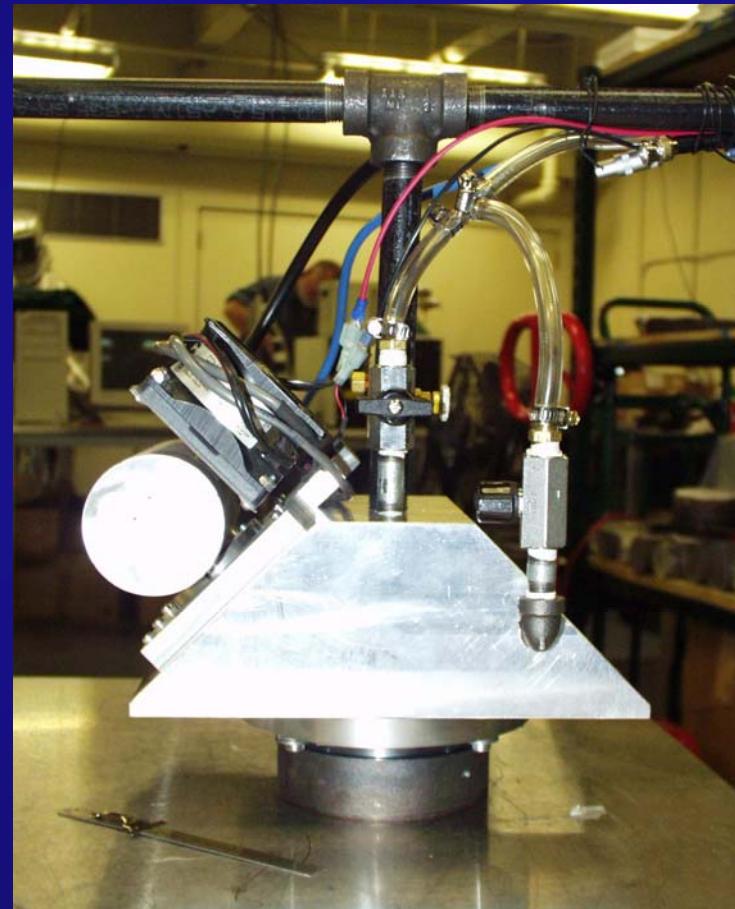


wTe CORPORATION[®]

Melt Cognition™

*Do with Liquid Metals what
wTe does with solid scrap.
Instantaneous composition
of liquid metal, on line, real
time.*

*JV Partners:
ERCo and MSI.*





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Spectramet and Melt Cognition Long Term Goal:

An Integrated Furnace System directly producing specification alloys from 100% scrap (e.g. Spectrametal™) deploying Melt Cognition Technology to Reduce Melt Time and Trim Final Composition real time, in situ.



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Questions?