Refining Industry By-Products: Representation & Analysis

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Purpose & Scope

- This presentation is meant as an informal guide for companies sending their pyrometallurgical refinery by-products for precious metal reclaim.
- All data presented was drawn from our operations with such materials, spanning the past 2 years.
- It is meant to offer insight from the inspector's standpoint on the job-site and from the lab of the third-party assayer.

Outline

- Refinery By-Products
- Containment & Transport
- Considerations for the Witness
- Preparation of the Material
- Oversize Material
- Assaying

Refinery By-Products

- Refinery by-products can come from many companies and streams: primary and secondary source refiners, scrap reclaimers, etc.
- The most common materials yielded from these processes are:

Slag:

Generally borosilicate, vitreous matrices.

Spent Crucibles:

Silicon-carbide, graphite, fused silica, or fired clay.

Spent Cupels:

Generally porous bone ash or magnesium oxide.

Considerations for the Witness

- Many view the role of their representative on-site in different ways:
  - Some believe the representative is there to simply “observe and report.”
  - Others expect the representative to act as a direct extension of their company’s interest and authority.
- Many times, the situation requires the representative to operate somewhere in-between these two standpoints.
- Establish best practices directly with the refiner and communicate them to your representative…

Considerations for the Witness (cont.)

- Communicate expectations:
  - What are your limits of variance in weight? Per container, or per lot?
  - Actions upon missing or broken seals.
  - How/when should issues be communicated and what are the expected actions on-site when a significant issue happens?
- Transmit all pertinent info:
  - Packing lists with drum counts.
  - Advised weights.
  - Material descriptions.
  - Special conditions/agreements with the refiner.
- Identify fiscal friction points:
  - Does the composition of your lot demand extra processing when sampling?
  - Does it require a reduction of services (i.e. no/partial representation during crushing)?
  - How many manhours/days are *too many*?

Containment & Transport

- Borosilicate slags and broken crucibles are heavy, sharp-edged, and hazardous.
- Consider the weight and structure of the material when identifying the proper container for transport:
  - Rigid containers: Gondolas, steel drums, Flo-Bins, etc.
  - Non-rigid: Supersacks.
- Accidents can cause a loss of material, ecological harm, and extra manhours.
- Consider additional packaging for soft containers to further protect the material (i.e. stretch wrap).
- Seal your containers properly and provide weights (ideally per container).
- Consider the preparation steps the material needs…

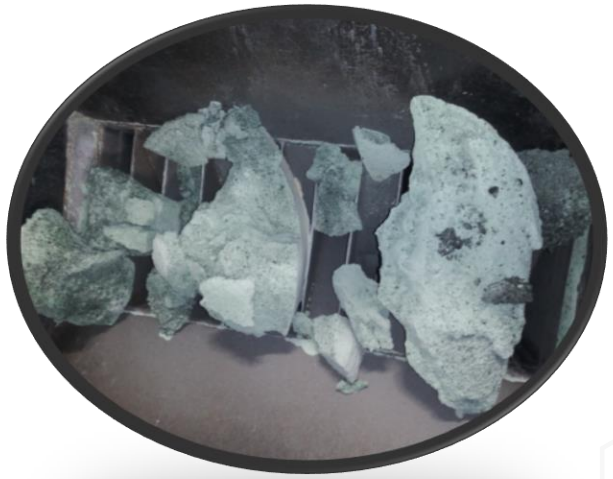
Preparation of Material

- Refinery by-products come in a variety of shapes, sizes, and hardness, requiring crushing/milling.
- Which is better for your business: crushing yourself before shipping, or the refiner crushing the material upon receipt?
  - If crushing before shipping, ensure that your lot meets an acceptable standard for your refiner to process immediately.
- Each refiner has different prep equipment and SOPs.
- Consider the refiner's process: what else must be done to your material in order to reflect good sampling practices?
- Combining different materials can be of economical benefit but consider the efficiency of preparing to homogenously sample the aggregate mix.

Preparation of Material (cont.)

- Borosilicate slags present another obstacle after being crushed:
  - The smallest fragments and dust have a sticky quality when wet.
  - The wet clusters of material can behave differently than the rest of the material does.
  - If these desiccate thereafter, the chunks become rock-hard.



- To avoid this, select the best container for transport and seal your containers well.

Oversize Material

- Screening a milled lot of by-products can yield oversize material.
  - Oversize can be left-over metallics from the refining process, non-metallics, stubborn material, or tramp material.
  - Oversize may be classified in two categories:
    - **Magnetic** (often devoid of precious metals).
    - **Non-magnetic** (often high in precious metals).
- The question is whether the oversize should be:
  - Sequestered/returned.
  - Discarded.
  - Sent to melt & settled.
- This is a unique question for each company (and perhaps each lot).
  - Is a resource like **XRF** available on-site to help in this determination?
  - Are the assay and processing costs more than the potential value of the oversize yield?
  - Ask about shipping or vault options with your rep or the other party.

Oversize Material (cont.)

- An example on the potential value of oversize material:

Example	Lot #	Material	Size	Result - %			
				Au	Ag	Pt	Pd
1	1	Slag	Fines	0.0111	0.0517	0.0002	0.0011
	2	Slag	Oversize	0.5742	1.5693	0.0057	0.1437
	VARIANCE		**Oversize:Fines**	**51:1**	**30:1**	**28:1**	**130:1**

→ **Oversize = 569 toz** (3.0% of total settlement weight) → **~ $5,000**

Example	Lot #	Material	Size	Result - %			
				Au	Ag	Pt	Pd
2	1-5	Slag	Fines	0.2927	0.8105	0.0030	0.0724
	6	Slag	Oversize	1.0279	2.1524	0.1736	0.6823
	VARIANCE		**Oversize:Fines**	**31:1**	**36:1**	**62:1**	**28:1**

→ **Oversize = 148 toz** (0.9% of total settlement weight) → **~ $2,500**

Assaying

- The best assay approach for most pyrometallurgical by-products is through pyrometallurgy—via Pb-fusion fire assay.
- Certain materials create obstacles in fire assay methods, if uncorrected. For example:
  - Silicon-carbide and fused-silica crucibles render the assayer's slag excessively acidic from powerful silicates, creating **regulus/matte**. Correctable with ample litharge.
  - By-product slags can have an unbalanced pH, requiring the addition of reagents to treat it with the assayer's flux.
  - Spent cupels can carry precious metals due to problematic elements (Se, Sb, As, etc.) causing the same retention of precious metals in the assayer's cupel. Correctable with reducing fire assay charge weights and adding wet chemistry methods on top of fire assay.

Assaying (cont.)

- It is important to select the right assayer for refinery by-products.
- For full precious metal collection, an assayer should:
  - Perform gravimetric fire assays and ICP-finish to analyze each precious metal.
  - Perform fire assay trials in triplicate (or more).
  - Rerun the slags of fire assay fusions to ensure proper collection and correction for problematic elements.
  - Use flux mixtures designed to treat the specific material at-hand and calculate the addition of reagents, as needed.
  - Utilize wet chemistry methods to analyze base metals, determine deleterious portions, or adjust for problematic elements in fire assay.

Material / Issue	Flux	Reagent
Basic pH slag	Neutral, with flour	Add borax or silica
Acidic pH slag	Neutral, with flour	Add soda ash or litharge
Graphite crucibles	Neutral/basic, flour-free	Calculate niter
SiC crucibles	Neutral, with flour	Add excess litharge
Rh in sample	Neutral, with flour	Add Bi_2O_3 or metallic Bi
Sulfides/mattes	Basic, flour-free	Add potassium carbonate

*Small example of some of the fire assay custom flux and reagent additives to treat specific refinery by-product materials.

THANK YOU!

For questions, quotes, and services, contact:

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