Best Practices in Gold and Silver Refining

John Fairley, Alan Gibbon

Limitation of Liability

Wallace Trading Limited (WTL) does not represent or warrant the accuracy of this presentation, and this information may be incomplete or condensed. It is not intended to form the sole basis for any evaluation of the subjects and issues discussed herein. All estimates and opinions included in this article constitute our judgement as of this date and may be subject to change without notice. WTL will not be held liable for the consequence of reliance upon any opinion or statement contained herein or any omission.
Wide ranging experience in Gold, Silver and PGMs Refining

Specialists in Developing and Improving:

- Pyrometallurgical & Hydrometallurgical Refining Processes
- Preparation & Sampling - High & Low Grade Refining Materials

Refining Operations Management:

- Inventory Management & Material Control Systems,
- Environmental Controls and Security.
- External Refining Contracts

E-mail: jf@wallace-trading.com
Website: www.wallace-trading.com
Best Practices in Gold and Silver Refining

- Very High Intrinsic Value Materials
  - Gold ~ $40,000,000 per tonne
  - Copper ~ $6,000 per tonne

- Strong Acids and High Temperature Melting

- Highly Competitive
  - Metal Recoveries – 99.9%
  - Low Cash Charges
  - Financing – Metal Pipelines & Prepayments
Best Practices in Gold and Silver Refining

- Best Practices in Inventory Management are Vital

- The Core Issue in Every Refinery
  - Inventory Control & Management
  - Trace and Find Every Gram

- IT - Integration of Paper Recording Systems & Physical Reconciliation
Best Practices in Gold and Silver Refining

- Real Estate:
  - Location, Location, Location
Best Practices in Gold and Silver Refining

- Gold and Silver Refining:
  - Inventory, Inventory, Inventory
Best Practices in Gold and Silver Refining

Presentation Objective

- Define Best Practices in Inventory Management
- Highlight Key Issues
  - Receiving,
  - Evaluation,
  - Refining,
  - By-Product Recycling
  - Liquid and Gaseous Emissions
  - Security
- Mass Balance Benchmarking
Inventory Management: Receiving

Integrated IT system

- Job identification for traceability.
- Integration with accounting system.
- Records job weights, assay, content and discrepancies.

Objective: Creation and monitoring of real-time inventory centre contents.
Inventory Management: Inventory Centre Mass Balancing

- Inventory control is as important as achieving a consistent pure product.
- Understanding inventory gains or losses is essential to the viability of the business.

- Based on processes, define individual Inventory centres to enable accurate mass balancing.

\[
\text{Inputs} = \text{Outputs} + \text{Work in Progress}
\]
Inventory Management: Melting and Sampling

- Homogenise materials to enable representative sampling
- Match furnace type to material
- Induction – high and medium frequency
  - Dore, jewellery scrap
- Gas –
  - Slags and residues

Sampling - vacuum pin tubes are more consistently accurate than button or drill sampling - speed of freezing prevents layering.
Best Practices in Gold and Silver Refining

Inventory Management
Internal Residues and External Materials

Heterogeneous inputs most challenging
Just blending not the answer:

- Small dense valuable particles
- Large low-density particles
- Fine particles to dust

Sampling must still be representative
Best Practices in Gold and Silver Refining

Inventory Management:
Residues treatment and Sampling

- Reproducible results do not necessarily indicate the correct answer
- It could demonstrate consistent bias
- Results must be validated

The mass balance is key
Best Practices in Gold and Silver Refining

Inventory Management: Residues treatment and Sampling

- Mechanical sampling is strongly recommended
- From the bulk to the analytical laboratory
- Consistent feed rate is required
- Results must be validated
Best Practices in Gold and Silver Refining

Inventory Management: Residues treatment and Sampling

Blending

• Mixed density materials are difficult
• Blender needs careful design or may compound the problem
• Spear sampling can give consistent bias where the material has segregated

Integrated mechanical sampling processes can produce representative samples from a wide range of inputs
Best Practices in Gold and Silver Refining

Mass Balance Benchmarking

• A mass balance...the only way!

• Best practice is regular monitoring of procedures and results.

• Periodic mass balances across inventory centres is recommended

Find every gram
Best Practices in Gold and Silver Refining

Inventory Management: Refining Processes

Dissolution

Aqua Regia and Wet Chlorination

- Batch processes
- Minimal inventory control issues
- Solution sampling

Courtesy Italimpianti
Best Practices in Gold and Silver Refining

Inventory Management: Refining Processes

Miller Chlorination

- Batch-continuous processes
- Complex inventory management issues
- Challenging sampling
  - Hygroscopic fume residues
  - End point determination
  - Silver chloride slag
  - Particulate losses to atmosphere
Bullion Product Manufacturing

Gold giveaway

- Automation minimises gold weight giveaway
  - Gold Value $0.40 per 0.01 g
  - Kilo bars – 1000.02 g
  - Requires effective statistical process monitoring.

- Blending minimises gold assay giveaway
  - Gold Value $0.40 per 0.001 %
  - Requires efficient laboratory support.
Inventory Management: By-products and residues

- **Air:**
  - Treatment route depends on fume composition

- **Liquid:**
  - Minimise at source
  - Dilution complicates inventory management

- **Solid:**
  - Highest values,
  - Heterogeneous
  - Homogenisation first stage
Inventory Management: By-products and Residues

- Liquid:
  - Slurries difficult to evaluate
  - Hydrolysis or cementation treatment
  - Both present difficulties for inventory management

*Impurities must exit refinery*
Inventory Management: External Refining

To achieve consistency:

- Negotiate and agree detailed preparation, sampling and assay protocols with external refiner
- Back up with detailed statistical data to assess for any bias.
- Effective independent or self-representation required to ensure protocols are followed
Inventory Management: Security

Personnel Security

- Refinery - 100% metal-free personnel on entry and exit - wand search, metal detecting arch, X ray.
- All personnel - contractors, visitors & VIP’s
Best Practices in Gold and Silver Refining

Inventory Management: Security

Building Security

- Interactive CCTV monitoring with close-scrutiny zoom and check.
- Well-defined, secure storage areas between processes.
Best Practices in Gold and Silver Refining

Inventory Management: Improvements via Process Technology

Objectives:

- Process flexibility – treat a wider range of inputs
- Reduced number of process steps – beneficial impact on in-house logistics and evaluation
- Reduce by-product production – higher overall yield with less value in fume, effluent and solid residues
Best Practices in Gold and Silver Refining

Inventory Management: Improvements via Process Technology

Methods:

- Wider use of:
  - Solvent Extraction
  - Ion Exchange Resins
  - Vacuum Melting Technology
  - Ionic Liquids

E-mail: jf@wallace-trading.com
Website: www.wallace-trading.com