



# Controlling losses in refining operations

*"Precious metals refining is both science and art"*

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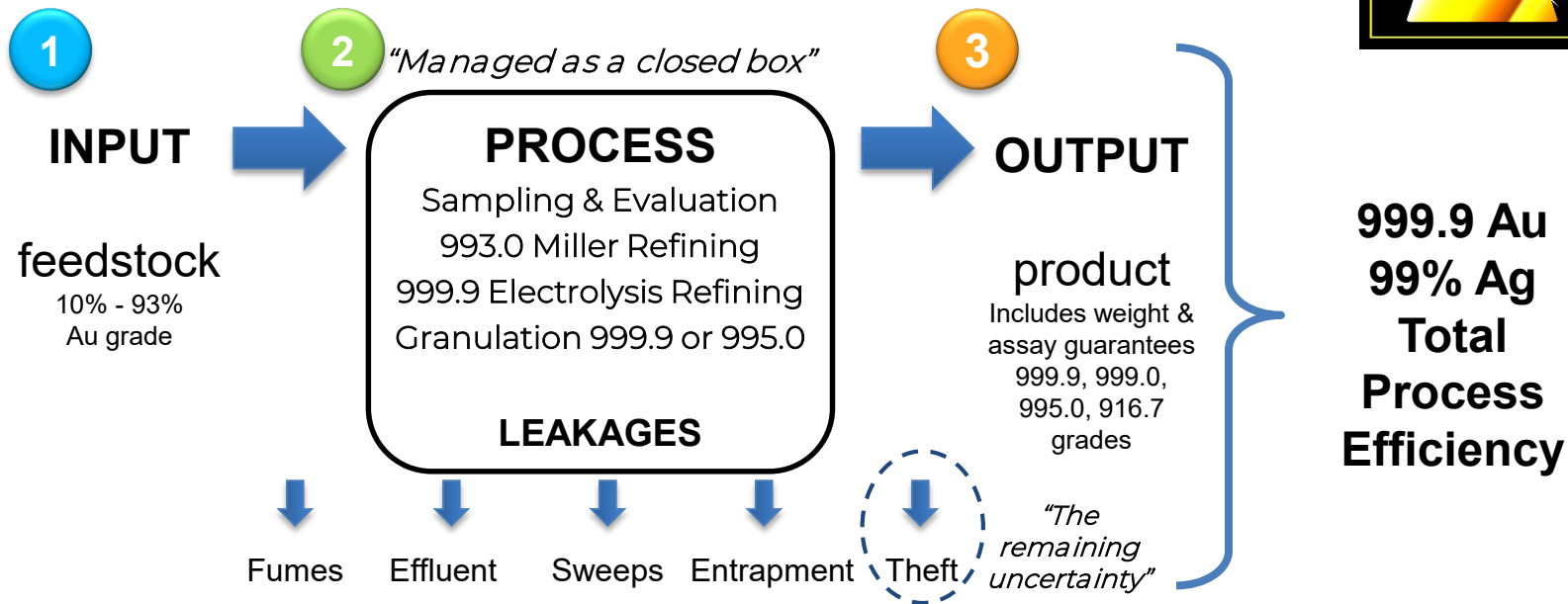
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## Who is Rand Refinery

- Founded in South Africa in 1921
- Refined over 50,000 tons of gold to date
- Owned by depositing mine shareholders – so everything we do is biased towards a fair deal for the depositing mine
- 46% RSA gold mine deposits, 54% African mine deposits
- 98% mined throughput (recognising that every ounce of recycled gold was once mined – this should be added to the accumulating ESG footprint of recycled gold)
- Certifications: LBMA referee, COMEX, SGE, ISO9002, ISO14000, ISO18000, ISO17025



## Basic Principle: Total Mass Balance of the Refinery



Based on the AMIRA P754 CODE for Metal Accounting Principles → Application audited!

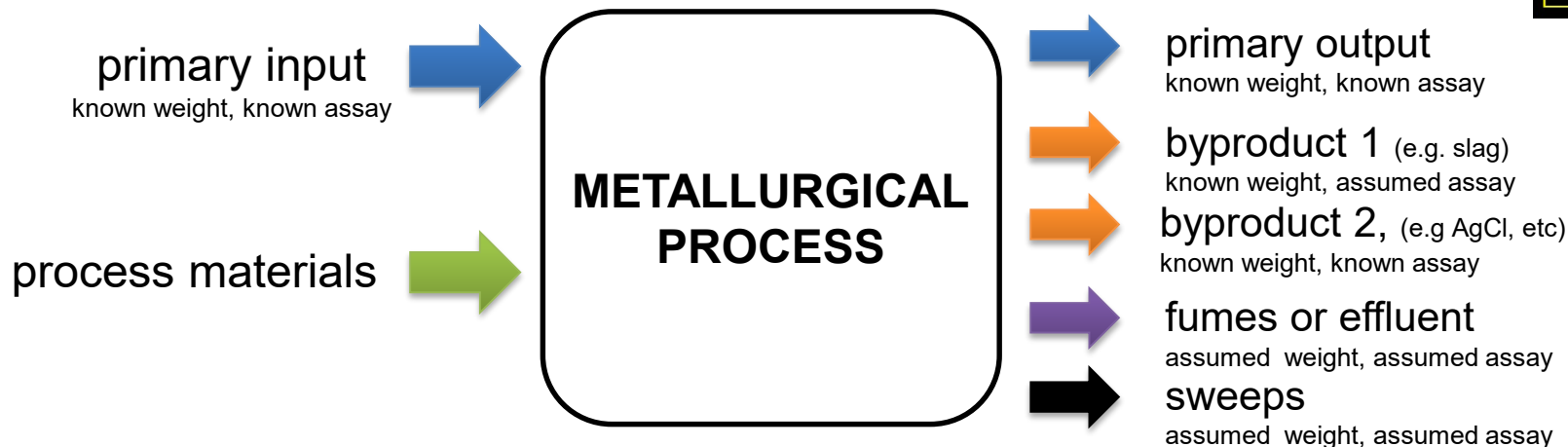


# For reference: The 10 metal accounting main principles

## Embedded in the Rand Refinery ERP (SAP) system

1. The metal accounting system must be based on **accurate measurements of mass and metal content**. It must be based on a **full Check in-Check out system** using the Best Practices as defined in this Code, to produce an on-going metal/commodity balance for the operation. The system must be integrated with management information systems, providing a one-way transfer of information to these systems as required.
2. The system must be **consistent and transparent** and the source of **all input data to the system** must be clear and understood by all users of the system. The design and specification of the system must incorporate the outcomes of a risk assessment of all aspects of the metal accounting process.
3. **The accounting procedures must be well documented** and user friendly for easy application by plant personnel, to avoid the system becoming dependent on one person, and must incorporate **clear controls and audit trails**. Calculation procedures must be in line with the requirements set out in this Code
4. The system must be subject to **regular internal and external audits and reviews** as specified in the relevant sections of the Code to ensure compliance with all aspects of the defined procedures. These reviews must include assessments of the associated risks and recommendations for their mitigation, when the agreed risk is exceeded.
5. Accounting results must be made **available timeously**, to **meet operational reporting needs**, including the provision of information for other management information systems, and to facilitate corrective action or investigation. A detailed report must be issued on each investigation, together with management's response to rectify the problem. When completed, the plan and resulting action must be signed-off by the Competent Person.
6. Where provisional data has to be used to meet reporting deadlines, such as at month ends when analytical turn-around times could prevent the prompt issuing of the monthly report, **clear procedures and levels of authorisation for the subsequent replacement of the provisional data** with actual data must be defined. Where rogue data is detected, such as incorrect data transfer or identified malfunction of equipment, the procedures to be followed together must be in place
7. The system must generate sufficient data to **allow for data verification**, the handling of metal/commodity transfers, the reconciliation of metal/commodity balances, and the measurement of accuracies and error detection, which should not show any consistent bias. **Measurement and computational procedures must be free of a defined critical level of bias.**
8. **Target accuracies for the mass measurements and the sampling and analyses must be identified** for each input and output stream used for accounting purposes. The actual accuracies for metal recoveries, based on the actual accuracies, as determined by statistical analysis of the raw data, achieved over a company's reporting period must be stated in the report to the Company's Audit Committee. Should these show a bias that the Company considers material to its results, the fact must be reported to shareholders.
9. **In-process inventory figures must be verified** by **physical stock-takes at prescribed intervals**, at least annually, and procedures and authority levels for stock adjustments and the treatment of unaccounted losses or gains must be clearly defined.
10. The metal accounting system must **ensure that every effort is made to identify any bias** that may occur, as rapidly as possible and eliminate or reduce to an acceptable level the source of bias from all measurement, sampling and analytical procedures, when the source is identified.

# The Metal Accounting Transaction



No metal move without the above transaction and paperwork attached for check-out, check-in validation

Every metal movement in the process value chain forces the above transaction with every field to be completed. Where “actual data-based” historic assumptions are used, the Metal Assurance functionary signs off on the agreed values for the year and a bias is annually reviewed

1

## Feedstock – metal accuracy starts here!



representative repeatable sampling + weighing accuracy + repeatable evaluation = foundation of metal accounting

### Sampling & Evaluation

#### Every deposit will have:

- 6 x fire assay prills to determine Au & Ag
- 2 XRF disks to confirm Au and 21 deleterious elements
- Be careful of Fe, Ni, Zn, Ir

### Weight Determination

#### Every deposit will have:

- Customer weight
- Wet receipt weight
- 3 x Dry weight (0.01%)
- Weight After Melt
- Settlement weight

Sampling theory statistical methods applied



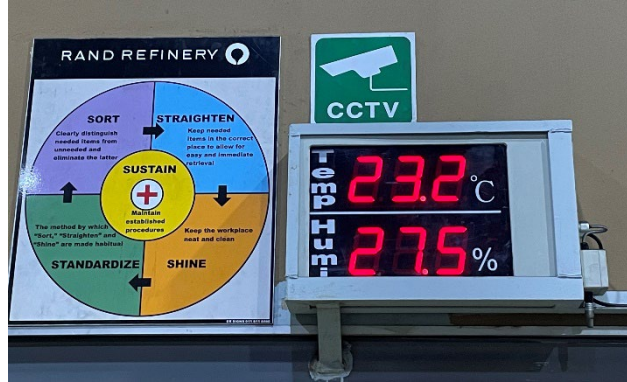


## Things to remember about mass balances

- We employ a total of 93 mass balances throughout the operations from 1kg – 1000kg
- Minimum significant numbers accepted = 5. Critical applications (buy/sell) use 7 significant numbers



*Scales drift – shield from airflow changes*



*Measure ambient conditions and develop a calibration policy, but not less than twice a day*



*Every mass balance must have it's own dedicated calibration weight that itself is calibrated annually*

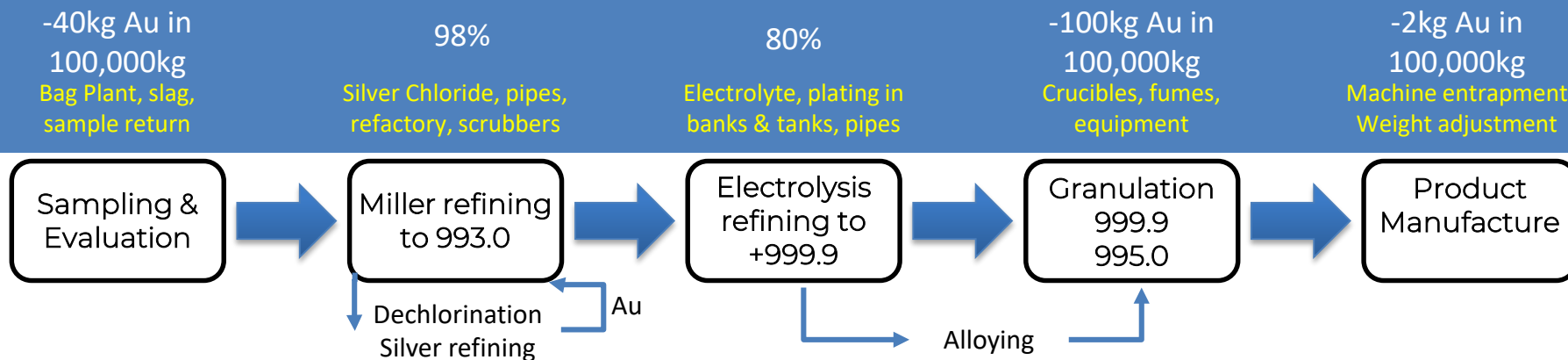
A mass balance must be sized correctly!

You cannot accurately weigh a 1 KiloBar on a 30kg mass balance!

Our motto: “every milligram matters, every second counts”

## 2 Processes – Losses and where to look

### Likely First Pass Efficiency



Some lessons that took us a long time to work out:

- If gold cathode crop or silver crystals are not perfectly dry before granulation, you may see perceived weight losses
- Installing settling tanks and recycling filter presses or catalytic recovery on EVERY effluent line out of the plant recovered, a surprising amount of gold and silver even after effluent were treated through precipitation



## Gold from sweeps and scrap recovery: +50kg per 100,000kg

- Gold has the propensity to go everywhere. Every item in the refinery is treated as gold containing!
- Every movement of human and material across the high security boundary constitutes risk.
- Once in the refinery, it stays there:
  - No contractor tools go out. Remains in the refinery.
  - As much as possible equipment are fixed inside the refinery (rotas ideal theft vehicle)
  - Industrial clothing remains in the refinery – incinerated at end of life
  - Everything “dies” by incineration or grinding inside the refinery to remove gold



*Sweeps crushing and metal recovery*



*Incinerated material for melting*



*Laundry inside – all sumps “trapped”*



*Material for incineration inside refinery*

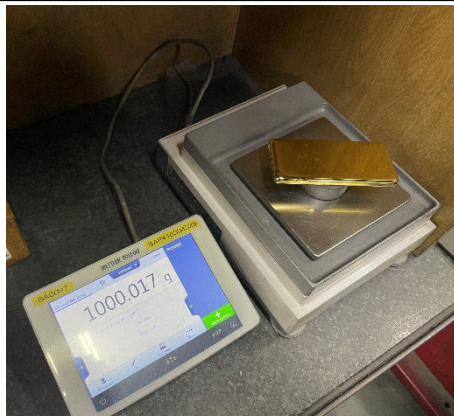
### 3 Product Output – everything is measured

- Biggest contractual risk – product movement to customer without payment release
- Biggest operational risk – weight and assay guarantees above nominal values: 25kg per 100,000kg
- E.g. 22ct KR coin guarantee is 20mg weight + assay at 91.70% = \$1.81/oz
- The above measurable product guarantees must be accounted for in the annual metal balance

Rand Refinery guarantees 1oz gold content of it's products by combined contribution of weight and assay



Weight adjustment of Kilobar



Final Kilobar weight



Precision strip rolling to 1micron for coins



Coin weight sorting by robot



3

## Product Output – quality control (rejects risk more losses)



*Silver crystal – default production is 999.9 purity bat has produced 999.99 purity for customers*



*Gold granules of small diameter at assay of +999.9 the default.  
Basis for quality products*



*Kilobars from the automated production line during QC*



*1 oz Minted Bar blank QC before minting*