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INTRODUCTION TO SAMPLING FOR MINERAL PROCESSING

Part 6 in a series "Effects on Mass Balancing"

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Review of Good Sampler Design

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Sampling, by definition, is the removal of a small representative portion from a total consignment or flow for the purpose of accounting or process control.

- Each particle of the sampling lot must have same probability of being included in the final sample
- A sample can only be considered representative, if each and every increment collected, in each of the sampling stages, is representative
- If both above conditions are met, then the final sample will be representative of the complete sampled lot

The theory of sampling indicates that in order to collect a representative sample:

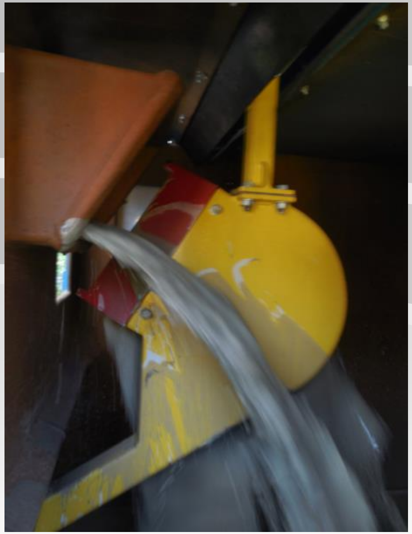
- The cut / sample must take all the cross-section of the stream
- The sampler’s cutter should intersect the stream at right angle to the flow
- The sampler’s cutter should travel through the stream at a linear and constant speed (speed deviations less than max +/- 5%).

Review of Good Sampling Design

AMIRA's P754 Code of Practice for Metal Accounting states:

- The metal accounting system must be based on accurate measurements of mass and metal content
- Sampling systems must be correctly designed, installed and maintained to ensure unbiased sampling and an acceptable level of precision
- It is vital that samplers are inspected and cleaned at least every shift. This requires that the complete cutter can be viewed. Submerged or encased cutters or nozzles cannot meet this requirement.

Cutter Inspection Port



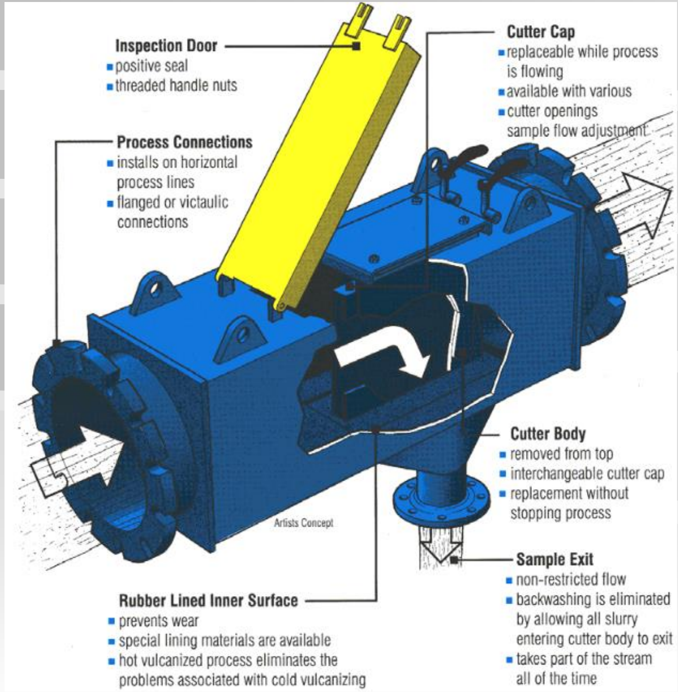
- Inspection ports
- Clean cutters
- Capturing entire flow
- No backflow

How is sampling inaccurate

Problem with non-representative samplers:

- The ratio of fines:coarse, or light:heavy, particles entering the fixed cutter or nozzle will vary even without fluctuations in the process. These kinds of samplers contain a bias, which is not constant.
- Segregation by particle size, density, etc. is always present as there can be no guarantee that the slurry to be sampled is homogenous
- Segregation caused by pipe bends or intersections, etc.
- These errors change over time due to fluctuations in feed tonnages, particle size, densities, flow rates, pressure, etc.

How is sampling inaccurate



Launder Sampler (shark fin) with static cutters:

- The portion of fine to course or light to heavy particles is affected
- Designed to work within certain flow rates, the bigger the particle the tighter the limits.
- Samplers are often flooded or have back pressure at exits if sample system is not designed correctly

Sampling inaccuracy example

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Final Tails	wt.%	Cu	Fe	Weight g/100g	
		%	%	Cu	Fe
+150	10.858	**0.120**	**1.640**	**0.01303**	**0.17806**
+106	10.678	0.070	2.030	0.00747	0.21677
+75	11.013	0.050	3.160	0.00551	0.34802
+38	17.649	0.040	3.920	0.00706	0.69185
+15	17.727	0.020	4.350	0.00355	0.77113
+6	20.025	0.020	4.080	0.00400	0.81702
+2	12.049	0.050	4.460	0.00602	0.53740
tail (calculated)	100.000			**0.04665**	**3.56026**

Final Tails	2.5% Change 1 (+150)			5.0% Change 2 (+150)	
	Weight g/100g			Weight g/100g	
	Cu	Fe		Cu	Fe
+150	**0.01335**	**0.18252**		**0.01368**	**0.18697**
+106	0.00747	0.21677		0.00747	0.21677
+75	0.00551	0.34802		0.00551	0.34802
+38	0.00706	0.69185	% Change in fractions	0.00706	0.69185
+15	0.00354	0.76945	14.3	0.00353	0.76776
+6	0.00399	0.81385	28.6	0.00397	0.81068
+2	0.00595	0.53048	57.1	0.00587	0.52357
tail (calculated)	**0.04687**	**3.55294**		**0.04710**	**3.54562**
	0.48224	**-0.20552**	**% Change in Assay**	**0.96447**	**-0.41103**

Detrimental effects to operations

The assays from samples are used for control and accounting purposes:

- Planning
  - Production targets
  - Plants need to make a certain amount of money to pay its bills and make a profit. This affects how much tonnage to push through a mill.
- Plant control
  - Grade / Recovery
  - Target values for these are set and accurate (unbiased) assays are required to achieve this.
- Metallurgical Accounting
  - Unbalanced results (poor sampling, assaying or weighing of stream)
  - Unaccounted losses (lack of measurement accuracy)

Metallurgical Responsibilities

- Troubleshooting, improving, and assessing plant performance
- Monitoring and controlling plant's operation
- Accounting and reporting metal production
- Assessing stock movements

Mass Balancing Effects – Constant Bias

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	Mass t	Assays %	Mass Metal t	Distribution Metal %
Feed	2,102,400	**1.75**	36,792	100
Conc	238,008	13.50	**32,131**	*87.33*
Tail	1,864,392	0.25	4,661	12.67

Feed biased +3.5%

	Mass t	Assays %	Mass Metal t	Distribution Metal %
Feed	2,102,400	**1.81**	38,080	100
Conc	247,726	13.50	**33,443**	*87.82*
Tail	1,854,674	0.25	4,637	12.18

Conc Difference (t)	-1312
Conc Difference (lb)	-2,892,501
$ Price / lb of Metal	6.50
Expectation Diff ($)	**-18,801,259**

- Data from composite samples
- Can been as revenues short of expectations ($18.8M/yr)
- Productions forecasts were incorrect
- Additional production losses likely because recovery would have been seen as higher than it really was – operators were happy!

Mass Balancing Effects – Fluctuating Bias (Precision)

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Item	Mass t	Err-1	Err-2	Diff	Mass Metal t	Err-1	Err-2	Diff
Feed	2,102,400	0	0	0	36,792	552	368	184
Conc	238,008	5,555	3,703	1,852	32,131	567	378	**189**
Tail	1,864,392	5,555	3,703	1,852	4,661	73	48	24

Conc Difference (t)	189
Conc Difference (lb)	416,571
$ Price / lb of Metal	6.50
Uncertainty Diff ($)	**2,707,710**

- Data from composite samples (Feed %1.5, Conc. %13.5 , Tails %0.25)
- 1-SD errors in mass balance calculations
- Additional errors comparing 1.5% and 1% sampling error
- Additional accounting uncertainty error of $2.7M/yr

Metallurgical Accounting Systems

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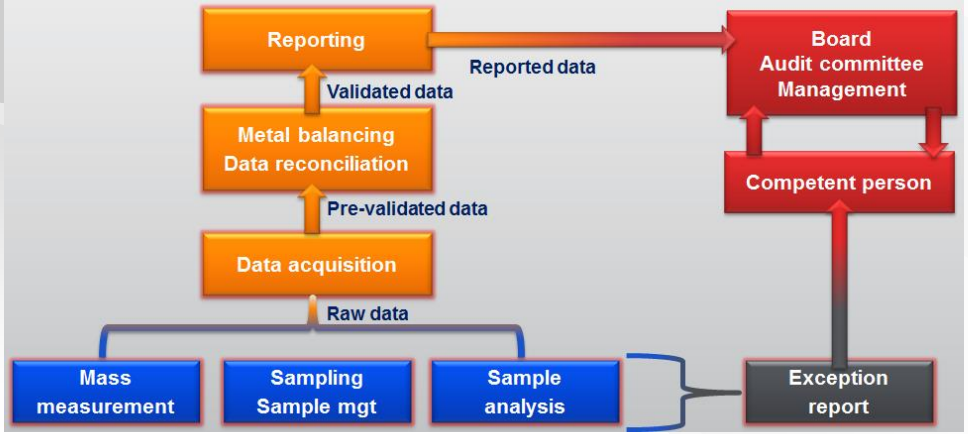
Metallurgical Accounting Systems (Eg. Algosys)

- collect, evaluate, reconcile data and perform mass balance computations
- reconcile production data for metallurgical accounting and inventorying purposes, enabling you to identify the precise location of metal losses and to optimize plant recovery.
- used to support decision-making, reduce risk, maximize profitability and ensure compliance.



Metallurgical Accounting Systems

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Metallurgical Accounting Systems (Eg. Algosys)

- For these systems to work properly, they require accurate, non-biased sampling
- The precision of measured values should be known or be able to be determined via testing
- Sampling errors find their way into metal accounting results
- Reconciled results are optimal estimates which satisfy the equations
- Users must be careful, in that reconciled values still carry estimation errors
- No amount of data processing will bring estimation errors to zero.
- These, estimations errors must be assessed and managed versus targets on a routine basis

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For more information you can always contact us at:
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