CONTENTS

CORPORATE GOVERNANCE

Corporate Governance attempts to:

- Motivate and drive Responsible Leadership.
- Aids accurate financial statements.
- Support sustainable company performance.
- Protect investors and stakeholders.
- Emphasize Process opposed to results

- **Sarbanes Oxley Act in the USA**
- **Combined code in the UK**
- **King III in South Africa**

- **The metal accounting outputs affects the financials**

(Gaylard, Randolph and Wortley, 2014)

METAL ACCOUNTING PROCESS

Process Inputs → **Processing Unit**

Opening Stock   Closing Stock

→ Process Outputs

Metal Accounting Balance (Metal Gain or Loss) = (Process Inputs – Process outputs) + (Opening Stock – Closing Stock)

Variances exist in opening and closing stock input. It is of importance to measure and monitor these variances for the purpose of quantifying the risk for control and risk management purposes. A robust statistical monitoring process will allow management to monitor these variances and will allow management track, quantify and improve the quality of the metal balance (AMIRA code, 2007).

METAL ACCOUNTING PROCESS

Shut and Cleanout Process → Retrieve Stock List from Inventory System → Compare Stock List with physical (weighting/ sampling) → Collect at least 5 samples for comparison

Certify assay and confirm precious metal content in closing stock ← Resolve variations (resample/treat) ← Analyse samples and statistically compare

Certified Precious metal content information transferred to financial information

This discussion propose a formalise evaluation strategy to assist in identify inconsistency between the different samples taken.
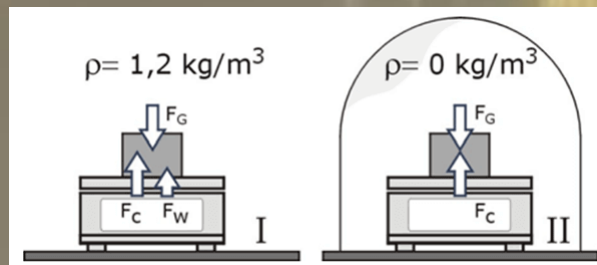
Doing this will aid the early identification of variance for rectification which will support the assurance of the metal accounting system.
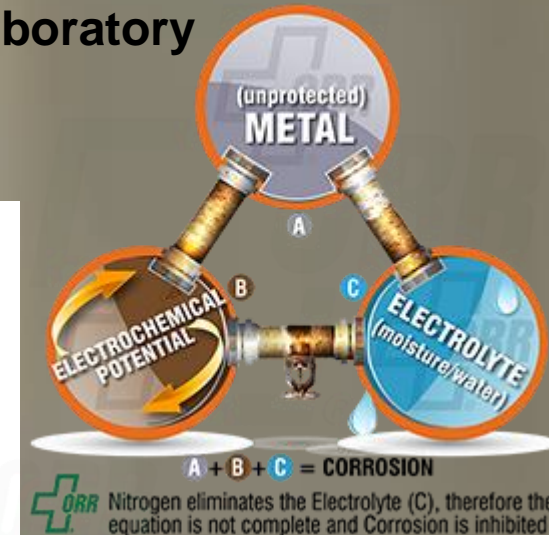
VARIANCES IN THE METAL ACCOUNTING SYSTEM

- Three types of inventories
- Process intake
- Process output
- Intermediatory inventory (more heterogenous)

- The above inventories has to be weighed and sampled.
- Plant instruments that measure and sample inventories are exposed to:
  - ❖ Noise, vibrations, dusts, high/low temperatures and corrosion
  - ❖ The above affects all Refinery departments i.e. Operations, Analytical Laboratory Maintenance, etc.
  - ❖ Shareholders/Stakeholders removed from these variations

THE CORROSION TRIANGLE

(unprotected) METAL

ELECTROCHEMICAL POTENTIAL — B

C — ELECTROLYTE (moisture/water)

A + B + C = CORROSION

ORR Nitrogen eliminates the Electrolyte (C), therefore the equation is not complete and Corrosion is inhibited

$\rho = 1,2\ kg/m^3$ $\rho = 0\ kg/m^3$

Air buoyancy correction

(Lachance, Leroux , Gariepy, 2015)
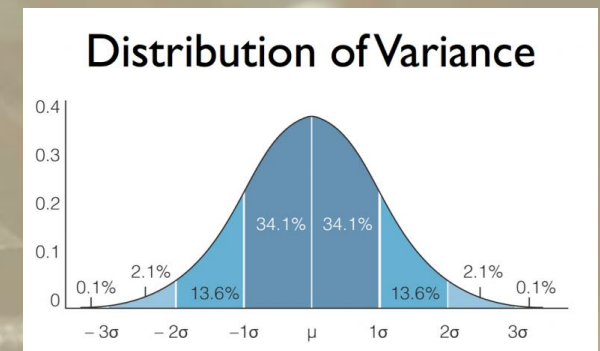
STATISTICAL DEFINITIONS: MEAN, BIAS, VARIANCE

- **Mean:** The mean of a set of n items of data is the arithmetic average of the series of measurements xi. The mean is usually designated by x with a bar above it.

$$\bar{x} = \sum_{i=1}^{n} x_i / n \qquad = (x_1 + x_2 + x_3 \cdots x_n)/n$$

- **Bias:** is the difference between the mean result of one or more measurements and the true value of the quantity being measured. It also can be seen as an ongoing difference between two, or more, measuring systems (AMIRA code, 2007).

- **Variance:** The sum of the squares of the differences between each measured value and the mean of the measured values, divided by one less than the number of measurements in the data set. Variance is a measure of the closeness between the data points. A high variance indicates low precision the data measurement process. Zero variance means perfect precise measurement however it could be not fully accurate (AMIRA code, 2007).

$$s^2 = \left[(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 \cdots (x_n - \bar{x})^2 \right] / (n-1) \qquad = \frac{1}{(n-1)} \sum_{i=1}^{n} (x_i - \bar{x})^2$$

Distribution of Variance

STATISTICAL DEFINITIONS : ACCURACY VS PRECISION
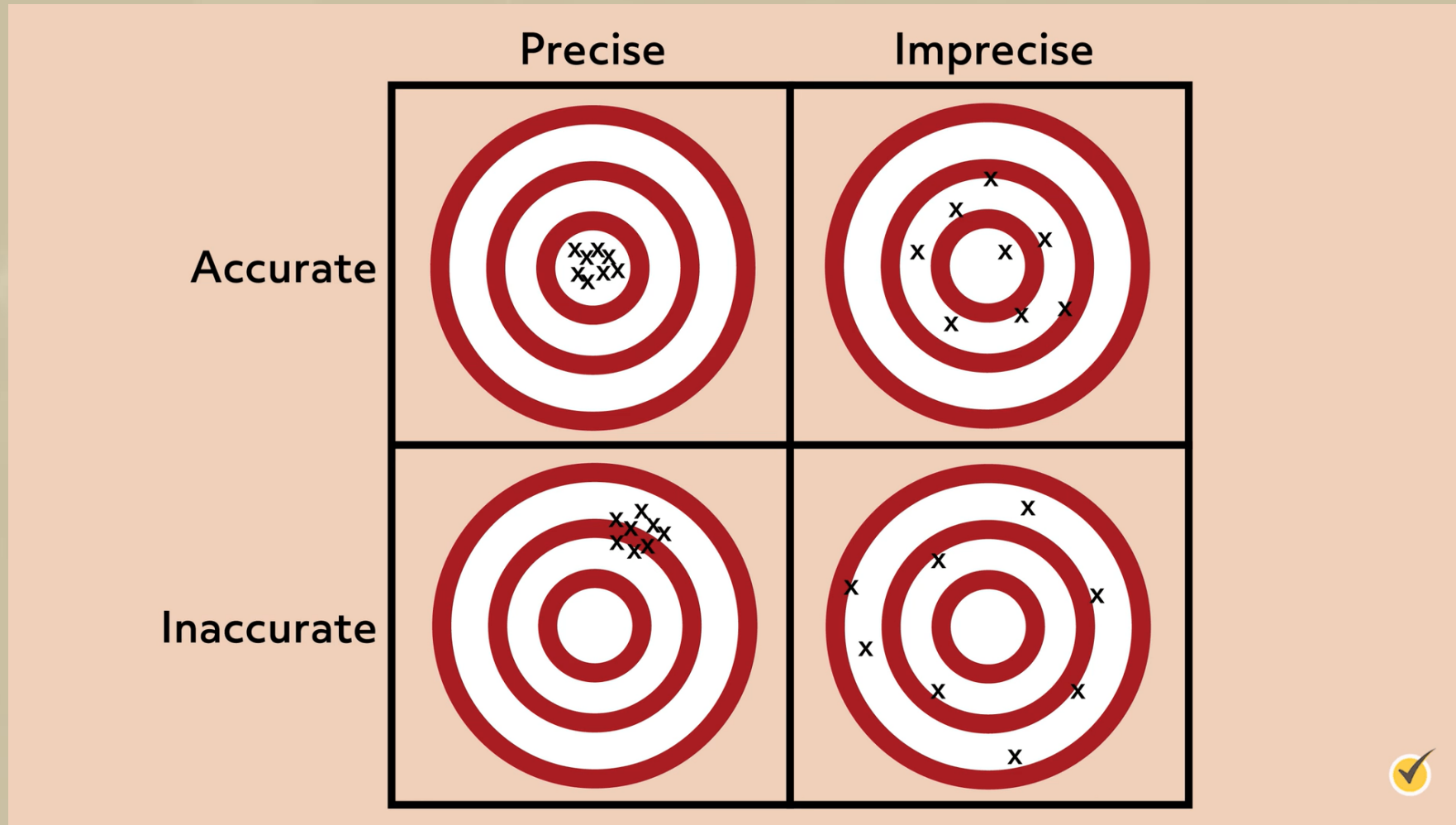

(Buckener, 1983)

STATISTICAL DEFINITIONS: PERCENTAGE VARIANCE, CORRELATION COEFFICIENT

- **Percentage Variance:** for the purpose of this investigation, sampling variance is defined as a measurement of the relationship between variance and the calculated mean. A high percentage variance indicates poor precision. The percentage variance is calculated by **variance/mean.**

- **Correlation Coefficient:** Measures the strength of the relationship between two numerical variables. The relationship of this variable can either be a linear, quadratic, logarithmic or exponential. The value of the coefficient can range from a perfect -1 to a perfect +1. The closer the value reports to -1 indicates a strong indirect proportional relationship, meaning that an increase in the one variable causes a decrease in the other variable.

Strength of correlation coefficients (Source: Asuero, Sayago, and Gonzalez, 2006).

0.90 to 1.00	Very high Correlation
0.7 to 0,89	High Correlation
0.5 to 0.69	Moderate Correlation
0.30 to 0.49	Low Correlation
0.00 to 0.29	Little if Any correlation
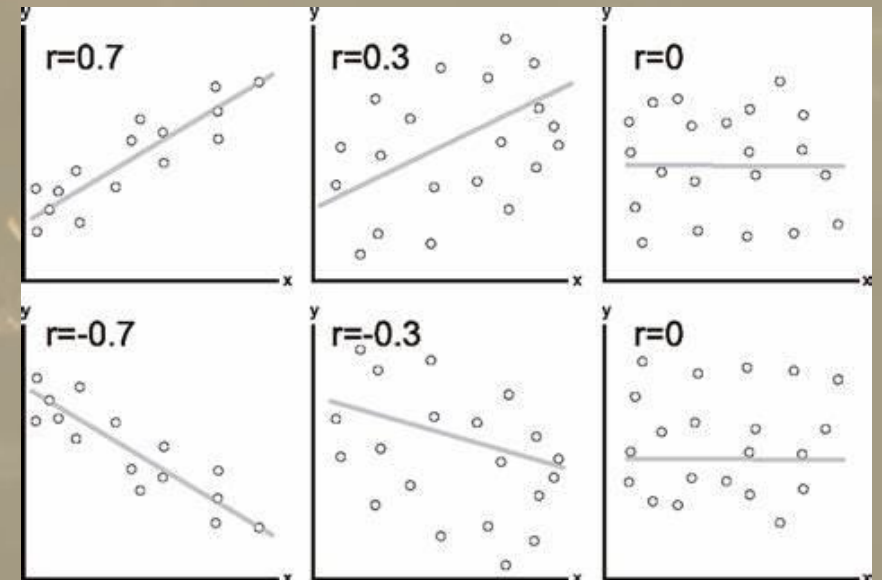
PERCENTAGE VARIABILITY

Batch	Sample 1 Assay (w/w%)	Sample 2 Assay (w/w%)	Sample 3 Assay (w/w%)	Sample 4 Assay (w/w%)	Mean Assay (w/w%)	Variance	Variance Percentage	
XXXX	94,65	95,58	94,63	94,60	94,87	0,23	0,24	

94,87/0,23

Percentage Sampling Variance

Outliers for Investigation

Batch No.

◆ Percentage Variance　　— Upper CTR Limit
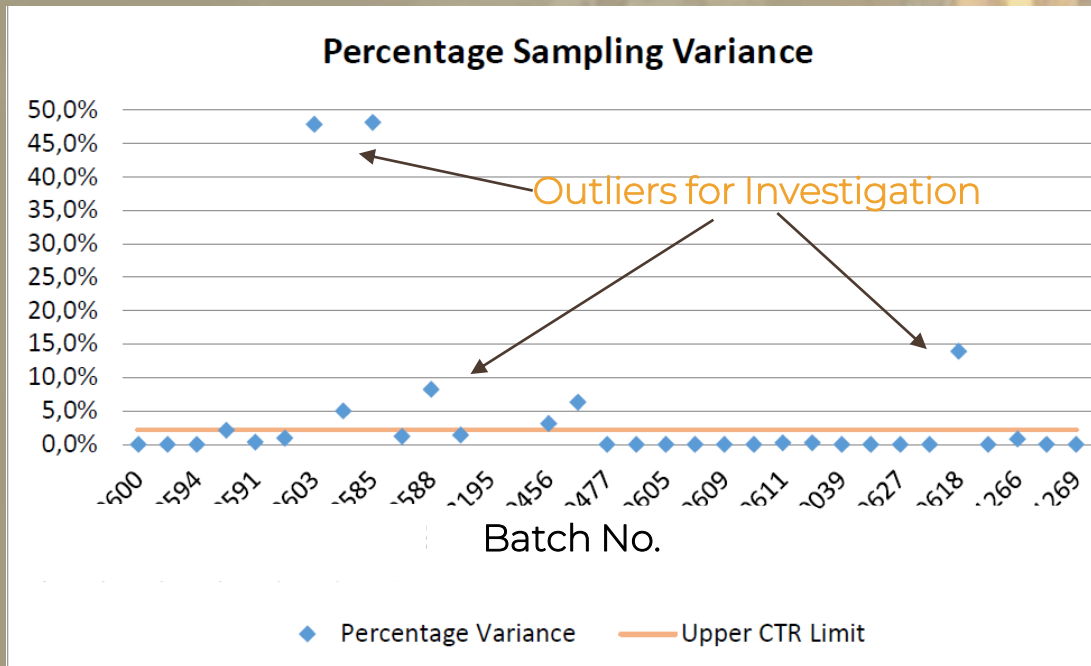
- **Some batches have higher sampling variance percentage compared to others.**

- **Investigate the outliers.**

- **Cross functional teams consisting of: Operations, Maintenance, Metallurgist and Laboratory focus on reoccurring issues.**

- **This facilitates the dissemination of knowledge within the organisation**

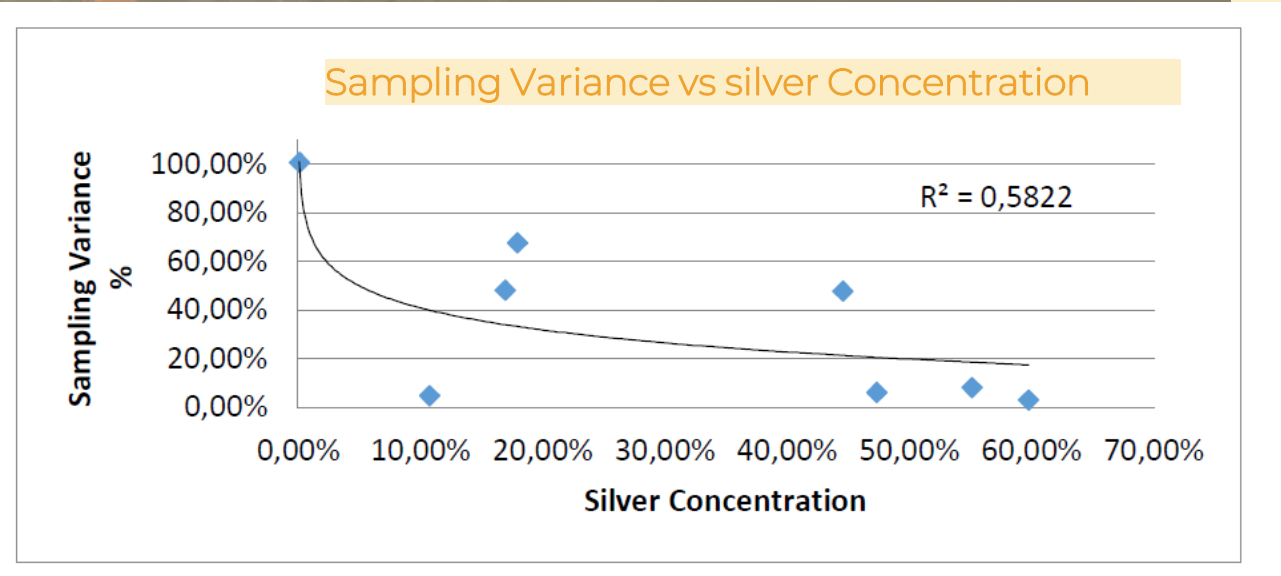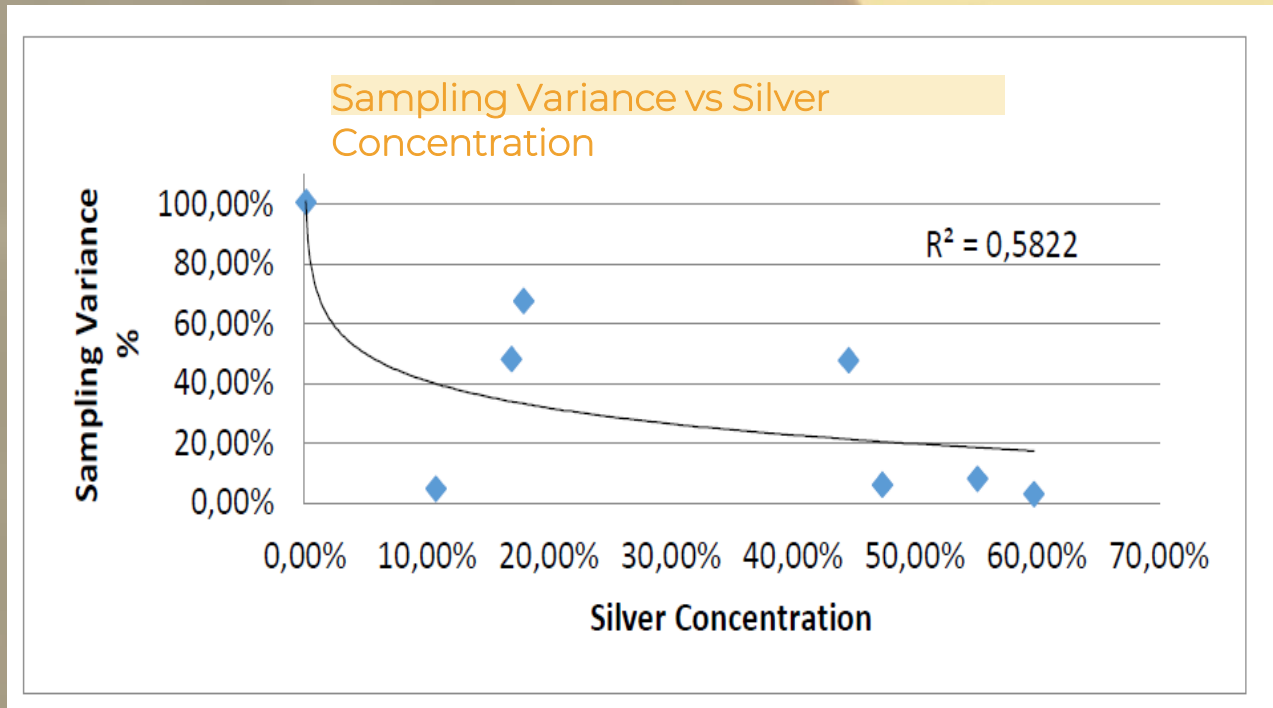# INVESTIGATION OUTCOMES: CORRELATIONS

Strength of correlation coefficients (Source: Asuero, Sayago, and Gonzalez, 2006).

0.90 to 1.00	Very high Correlation
0.7 to **0.89**	High Correlation
0.5 to 0.69	Moderate Correlation
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Batch Number	Au Assay (w/w%)	Ag Assay (w/w%)	Sampling Variance %
603	2.84%	44.57%	47.90%
582	63.85%	10.74%	4.98%
585	34.42%	16.94%	48.17%
588	12.47%	55.13%	8.25%
195	52.77%	0.10%	100.67%
204	55.02%	17.92%	67.70%
456	10.62%	59.77%	3.15%
473	34.07%	47.35%	6.33%

Sampling Variance vs silver Concentration

$R^2 = 0.5822$

PERCENTAGE VARIANCE OUTLIERS - CORRELATIONS

Sampling Variance vs Silver Concentration

$R^2 = 0,5822$

Sampling Variance %

Silver Concentration

Correlation suggests that high silver concentration reduces sampling variability.

It appears the silver dilutes the impurities such as Fe and Ni.

The latter two elements have high melting points and contributes to the heterogenous.

Sometime remelting and resampling do not work. Either fluxing or diluting the impurities with either silver or copper will enhance the homogenous nature of the melt
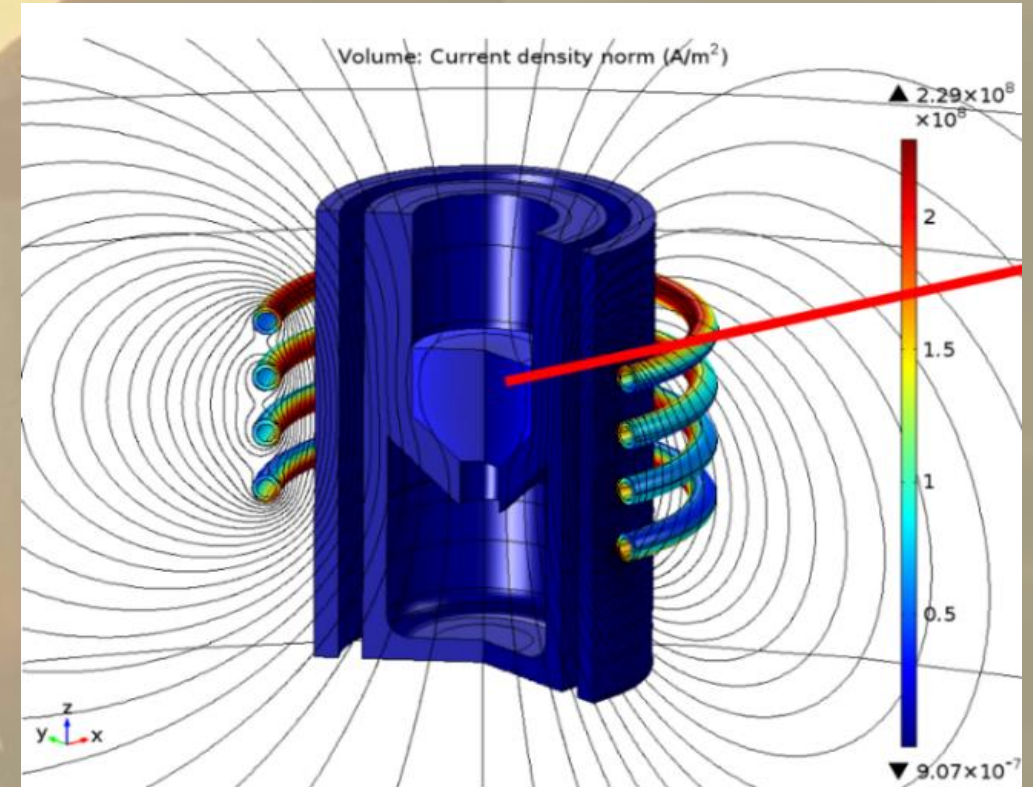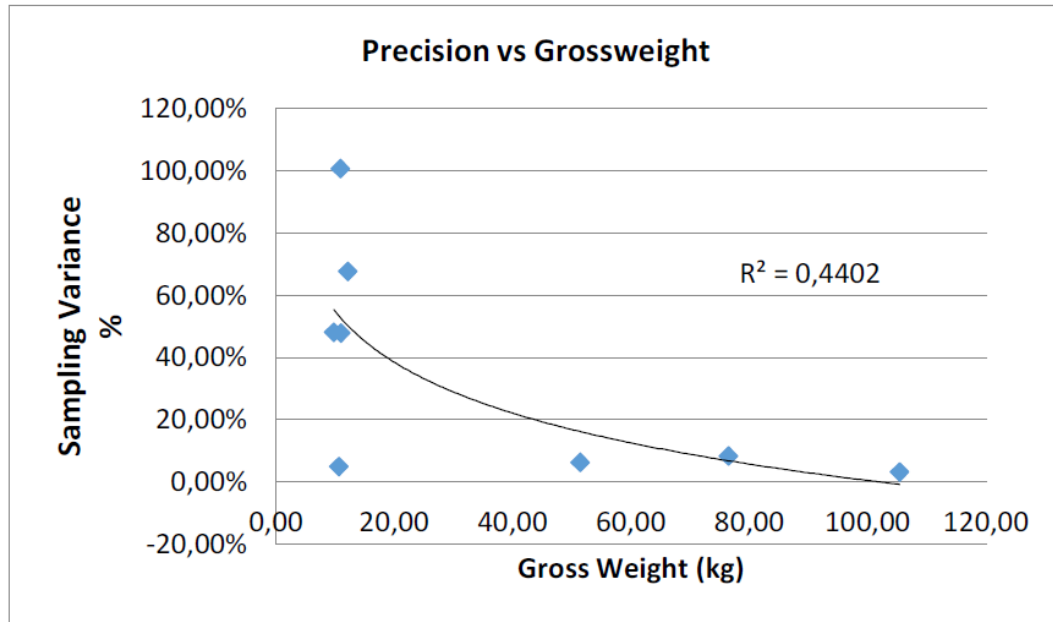
Correlation coefficient = (0,5822) ½ = 0,7630

High Correlation

PERCENTAGE VARIANCE OUTLIERS - CORRELATIONS

Scatter Plot with logarithmic trend line between precision and gross weight

Precision vs Grossweight

$R^2 = 0{,}4402$

Volume: Current density norm (A/m^2)

Correlation coefficient = 0,66 i.e. Moderate correlation

- **Induction furnaces has a magnetic field that agitate the molten liquid. This enhances the homogenous nature of the melt.**

- **It is important to ensure that the molten metal has adequate level and that the metal is exposed to the magnetic agitation.**

CONCLUSION

- Metal accounting practices impacts on the organisation's financial performance. The quality of the metal accounting balance rests on managing the variabilities of the mass, sampling and assaying practices.

- A typical closing stock list was produced following a physical stock take. Percentage sampling variability was calculated and the results were reported on a scatter plot with an upper level control limit. This allowed management to detect outlaying sampling variances.

- From the data presented, 8 batches indicated high levels of sampling variability and were further investigated.. After the root causes was identified, the appropriate corrective actions was identified and incorporated into the management system.

- It was found that the gross weights of the batches and silver concentration reported a relationship with the percentage sampling variability. The silver concentration in the molten metal alloy dilutes the effect of impurities and therefore reduces heterogeneity and improves the probability of producing presentative sampling.

- The proposed method allows management to identify melts with high levels of sampling variability and consequently allows management to investigate the phenomena to improve the quality of the metal balance and consequently reduce financial risks.

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