Implementing proactive Quality Assurance Quality Control (QAQC) and Quality Management (QM) practices at Coal Testing Laboratories

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Many commercial coal testing laboratories are accredited to ISO 17025[1] – General requirements for the competence of testing and calibration laboratories. There is an expected reliance in the Coal mining industry that the laboratory adheres to all elements of this standard in between successive accreditation audits conducted every 18 months by the independent accreditation body, National Association of Testing Authorities (NATA).

In the absence of proactive QAQC & QM practices monitoring the quality of the information reported by laboratories, potential issues impacting production decisions and reconciliation results are only determined in a reactive manner.

In addition, for mining companies working with several internal and external laboratories across the supply chain, the management of the logistics, practices and information becomes very challenging and time-consuming, impacting the company's ability to track laboratory results as key inputs in a production and reconciliation perspective.

The absence of proactive QAQC & QM practices results in a sub-optimal/reactive approach in the Coal industry, increasing the risk of short-term unaware production gaps related to quality, increased time required for quality breach investigations, the absence of a holistic approach/monitoring in the value chain, and the financial impact for the business performing under sub-optimal conditions.

This paper aims to show the journey towards the implementation of a new proactive QAQC and QM program, where now the quality of many different laboratories across the supply chain can be monitored and linked with global reconciliation results, as an improvement opportunity to complement the current industry standard ISO 17025 accreditation and Proficiency Round Robin approach.

Introduction

The current benchmark, as a QAQC program in the Coal mining industry, is the alignment of laboratory practices to ISO requirements. The vast majority of commercial (and some non-commercial) coal testing laboratories in Australia are accredited to ISO 1702511. There is an expected reliance in the Coal mining industry that these laboratories adhere to all the elements of this standard in-between successive accreditation audits conducted by the independent accreditation body, National Association of Testing Authorities (NATA). NATA's standard audit frequency is 18 months and therefore, in the absence of a proactive QAQC & QM practice monitoring the quality of the information reported by laboratories for customers, potential issues impacting production decisions and reconciliation results can only ever be determined in a reactive manner and information's quality only rely on laboratory's internal QAQC. In other words, a number of issues could arise 'unchecked' for laboratory's customers during the 18 months in-between these independent laboratory technical reassessment audits, issues that can potentially impact on the quality (precision/accuracy) of the results being reported by the laboratory to their customers resulting in unplanned out of specification product and the like. A robust proactive approach to QAQC and QM would identify these types of accuracy and precision issues before they become an issue.

Current reactive QAQC and QM coal industry practice

Reactive by its very definition is always after the fact, investigations into quality breaches are conducted after the train leaves the mine for the port or after the ship has loaded and set sail. Quality breach investigations take time to perform and tie up valuable resources in response to a situation rather than controlling it. Reactive QAQC and QM practices are backward looking and provide limited opportunities to introduce opportunities for continuous improvement.

Typically, reactive QAQC & QM programs are ad hoc in nature, for example: in response to a quality breach a Round Robin program might be organised to test the laboratory against another one, or many in an attempt to identify a bias or trend.

In a reactive QAQC environment, elements that affect sample analysis such as laboratory calibrations, compliance to national or international standard methodologies and the results of the laboratory's internal QC program might only be reviewed by the customer following a quality breach. This is because of industry expectations of the ISO17025 accreditation process creating a false

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sense of confidence and reliance on compliance is a driver of this reactive environment.

A reactive approach to QAQC & QM may involve the following elements:

- External Coal proficiency Round Robin program to monitor technical competence of testing laboratories.
- On-site technical audit to review a laboratory's operation to ensure methods, equipment, personnel, QC, calibration, result validation and reporting are fit for purpose.

This approach only provides information of a snap shot in time and does not really go far enough to identify emerging trends or the presence of true bias.

Proactive QAQC and QM

The requirements of proactive approach to QAQC and QM involve the following key components (Dominguez, 2019[2]):

- Quality Assurance (QA), refers to the plan in terms of controls, tools and practices that need to be implemented to assure the quality of all data or deliverables ("where, what and when to apply"). On Sample Analysis, the basic controls should target:
    - Laboratory calibrations that shall be performed for major and minor elements, because of the impact on the assays reported.
    - Laboratory internal QAQC process to review assay results by batch before results are reported.
    - On-site technical laboratory audits to ensure the previous two points are being performed as per prescribed cadences.

- Quality Control (QC), refers to the thresholds used to assess (approve or reject) QA performance".
    - Round Robin proficiency programs to monitor technical competence of testing laboratories.
    - Coal Reference Materials (Coal RMs) to monitor laboratory accuracy and precision at low-mid-high grade ranges/saturations.

- Quality Management (QM), refers to:
    - Continuous monitoring stage to proactively determine control performance deviations.
    - The precursor of appropriate corrective actions to close gaps (escalation), especially trend analysis (by ranges time and/or grades).
    - Recognise the good work.
    - Final verification step to check the gap has been closed.

Implementation of a more proactive approach

In order to implement a more proactive approach, the following elements are suggested for the coal industry, to complement those discussed in the reactive approach:

- Arrange for regular on-site technical audits to be conducted in-between the 18 month NATA ISO17025 accreditation audits. These technical audits must review the laboratory's operation to ensure methods, equipment, personnel, result validation and reporting remain fit for purpose in-between accreditation audits. In these audits also ensure that the prescribed cadence for calibration and internal QC activities are maintained. **Figure 1**, shows an example of a laboratory calibration schedule.

CALIBRATIONS 2022 — Due | Overdue | In progress | Complete

LAB/PTL	Task:	Frequency:	January	February	March	April	May	June	July	August	September	October	November	December
EXTERNAL	Balance Masses - NATA Source (external) Larger masses	Yearly												
EXTERNAL	Balance Masses - NATA Source (external) smaller masses	3 Yearly												
LAB/PTL	Balances Analytical - One Point Check	Monthly	24/01/2022											
EXTERNAL	Balances Analytical - Repeatability (external) - ensure to compare against 3 yearly calibration report	6 monthly (mixed over the year) various												
EXTERNAL	Balances Analytical Calibration - NATA Certificate Issued	3 yearly - Due 05/2022												
EXTERNAL	Analytical & 300kg - Service by NATA Reg. Authority	6 monthly												
LAB	Relative Density Bottles	3 monthly if in use												
LAB	Crucible Swell Apparatus - Temperature Check	Monthly												
LAB	Volatile Crucible Register	Yearly												
LAB	Combustion Furnaces - Temp. Ck	Yearly												
LAB	Ash Fusion Furnace - Temp. Ck	3 monthly if in use	25/01/2022											
LAB	CHN Truspec Furnace - Temp. Ck	Yearly												
LAB/PTL	Gray King Furnace - Temp. Ck - upon use	Yearly												
LAB	CHN/Sulphur Furnace - Temp. Ck	Yearly												
LAB	S632 Sulphur Furnace- Temp. Ck	Yearly												
LAB	Volatile Furnace- Temp. Ck	6 monthly												
LAB	ASTM Volatile Furnace- Temp. Ck	6 monthly												

Figure 1. Example laboratory calibration schedule.

- Arrange coal proficiency Round Robin programs to monitor the technical competence of testing laboratories across the coal quality supply chain. This approach allows the companies to review all of its laboratories across the supply chain (>20 laboratories). Robust Z-score statistics are reported for each analysis parameter reported by each laboratory in each program, Z-scores greater than ±3 are identified as outliers.

  In the past, data management was difficult and time consuming, and all the setup for the visualisation process used to take days to be compiled. Currently, formats can be developed in Spotfire and the visualisation process (in different types of graphs) now takes few seconds. For example, visualisation of the Z-scores in Box Whisker format for each parameter allows for trending and comparative analysis to be performed. **Figure 2,** shows a Box Whisker plot of Z-scores for individual laboratories across 5 different organisations for ash. This visualisation enables the direct comparison of 26 laboratories in the one view making it easier to identify potential intra and inter laboratory trends and biases, and also, has application in supporting the Reconciliation process across the coal quality supply chain.

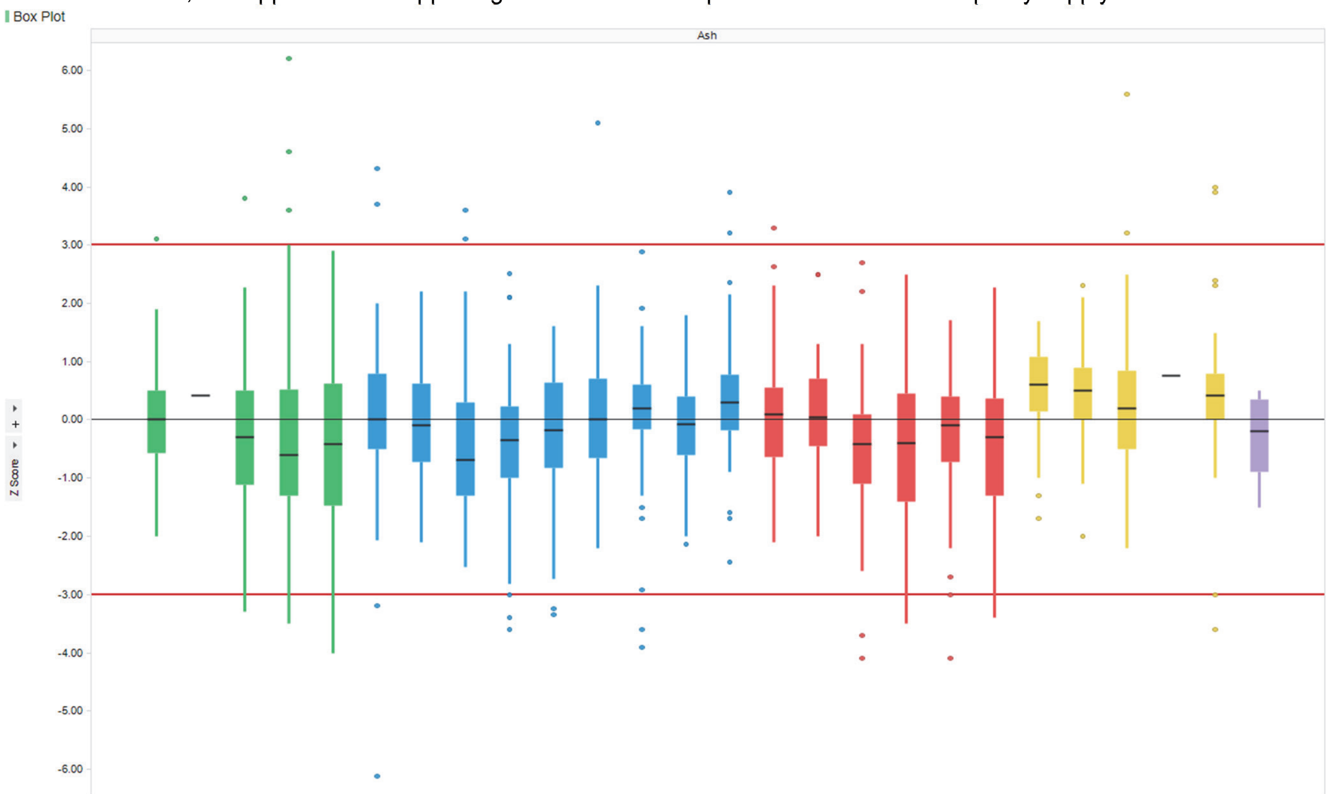

Figure 2. Box Whisker plot of Z-scores for individual laboratories across 5 different organisations for ash.

- On a sampling perspective, in previous years, samples used in the Round Robin used to be prepared and analysed, meaning different sources of error impacting the final results, for this reason coal pulverised and homogenised Reference Material (RMs) is now used as blind samples, allowing the company to review the precision and accuracy of analytical results all of its laboratories across the supply chain. For each coal RM the difference between each laboratory's result and the reference value (delta) is monitored for each parameter against the method reproducibility (R) limit for that parameter, deltas greater than ±R are identified as outliers. **Figure 3,** shows a Box Whisker plot of the differences between laboratory results and the coal RM reference parameter value for individual laboratories across 4 different organisations for Ash. This visualisation enables the direct comparison of the precision and accuracy of 23 laboratories in the one view.

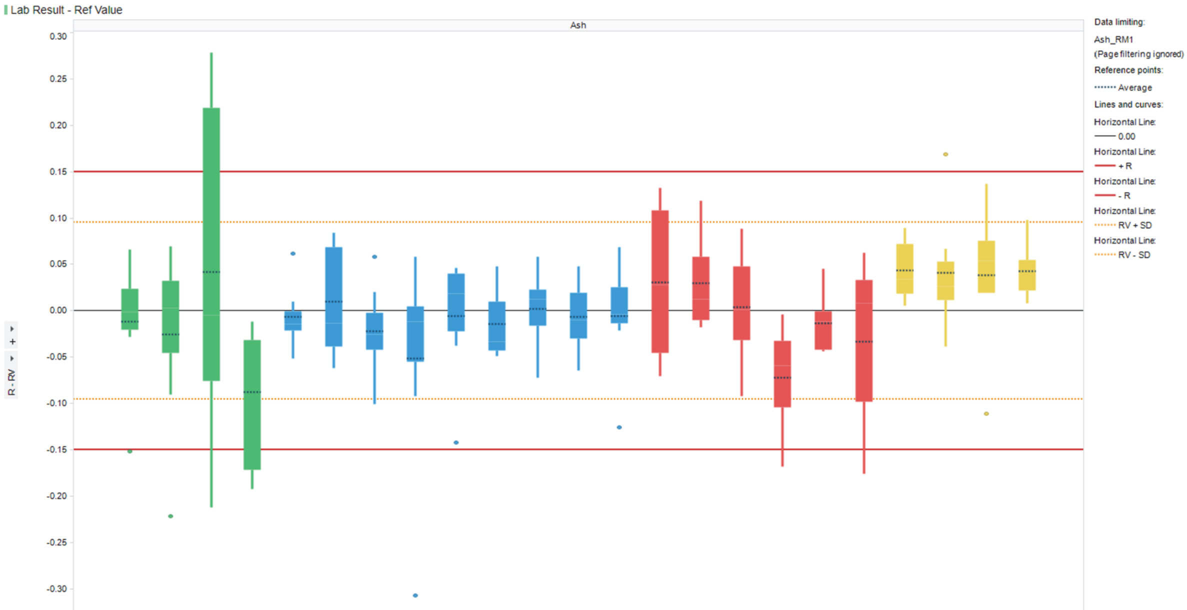

Figure 3. Box Whisker plot of the differences between laboratory results and the coal RM reference parameter value for individual laboratories across 4 different organisations for Ash.

Figure 4, shows the standard score 3 month moving average plot. The standard score is the number of standard deviations by which the laboratory result is above or below the reference value of the Coal RM. This visualisation enables the direct comparison of emerging trends or bias of 23 laboratories in the one view.

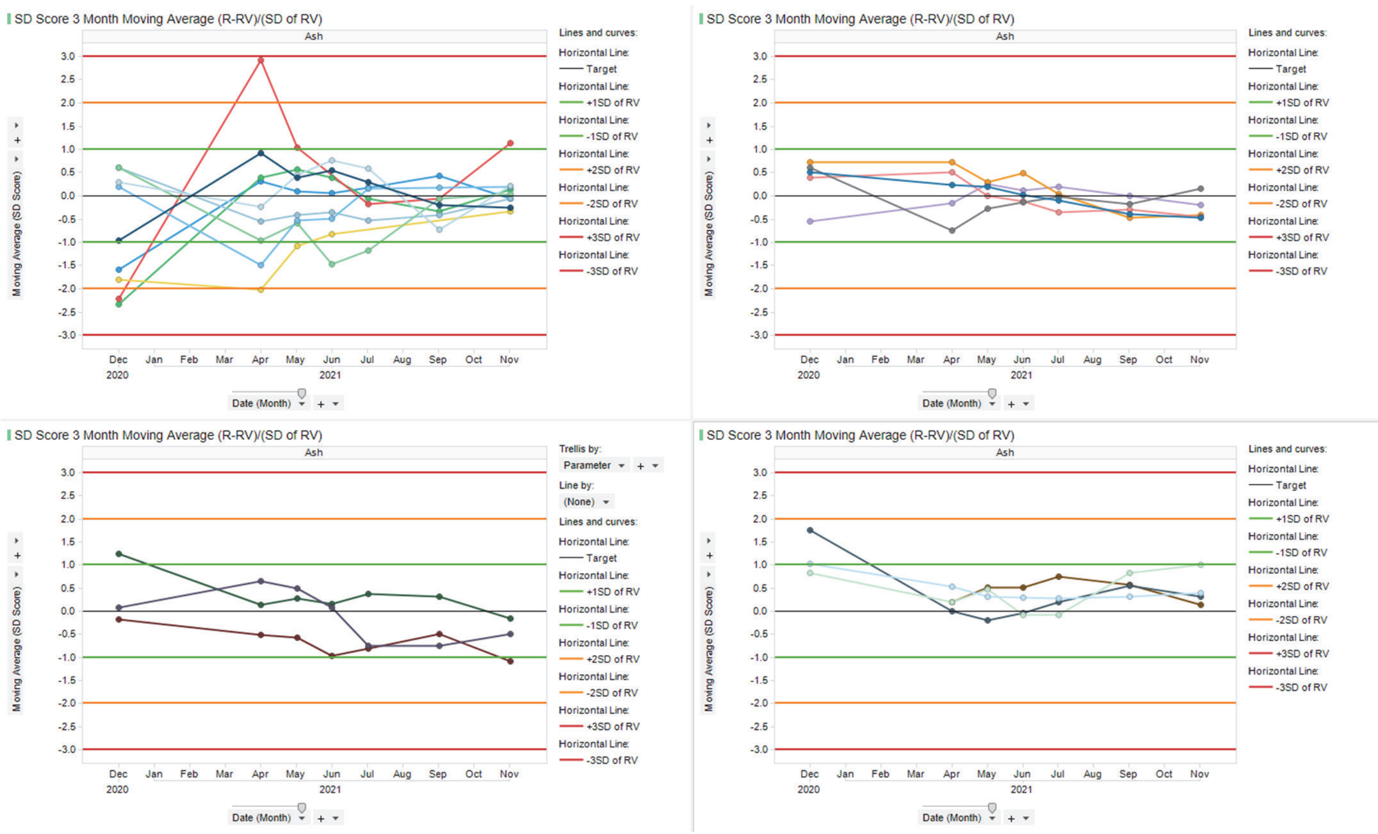

Figure 4. Standard score 3 month moving average plot for individual laboratories across 4 different organisations for ash.

Because of the logistical challenges related to the quality management of >20 laboratories, in different sites across the coal quality supply chain, as a first step towards the proactive approach, laboratory internal QC data is supplied from all the laboratories and imported into a QC dashboard which allows the company to regularly review the internal QAQC processes used to review assay results by batch before reporting. **Figure 5,** shows the difference between each QC sample result and the QC sample's reference value. This visualisation enables the direct assessment of individual laboratories on a short term perspective, enabling the monitoring and detection of emerging trends or bias more proactively than the old assessment every 18 months.

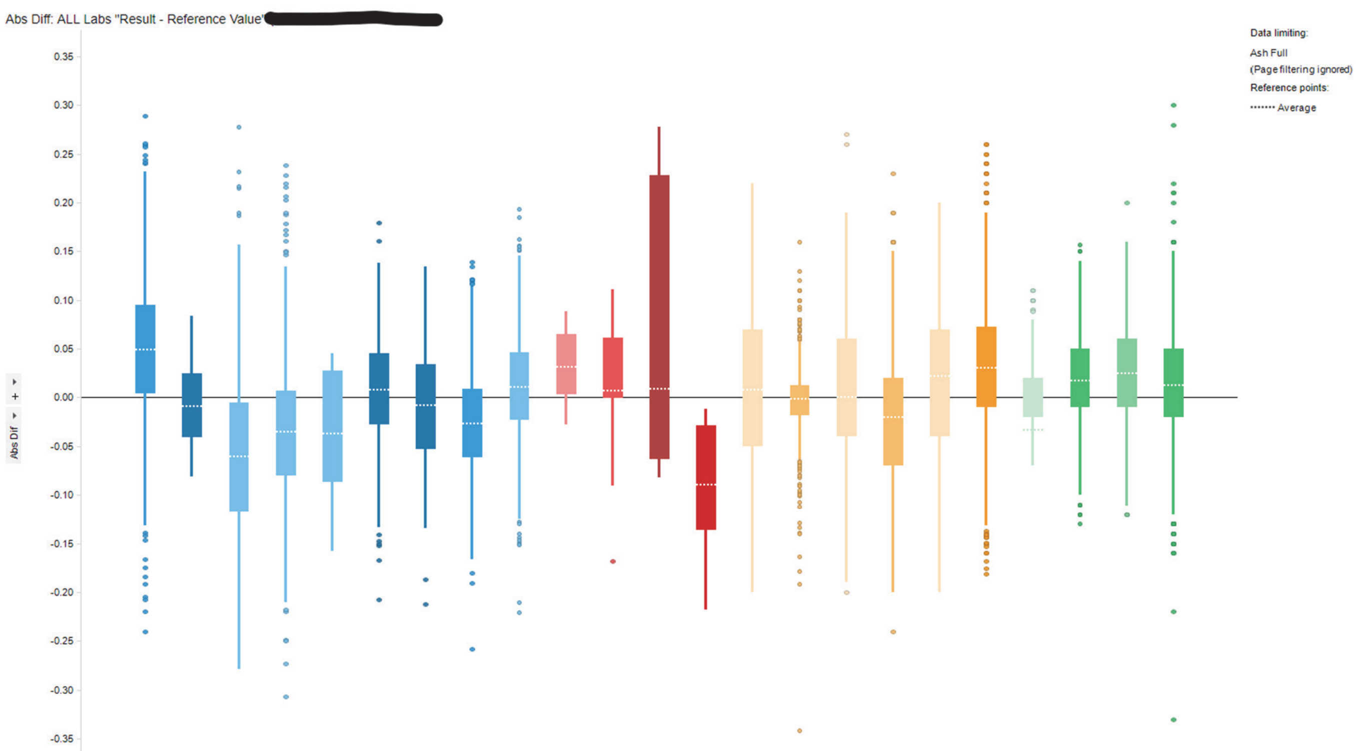

Figure 5. Box Whisker plot of QC data (difference between QC result in each assay batch and QV reference value) for

individual laboratories across 4 different organisations for ash.

Figure 6, shows the daily QC run chart (difference between QC result in each assay batch and QV reference value) and monthly Box Whisker plots of QC data for 3 laboratories in the same organisations for ash. This visualisation enables the identification of emerging trends or bias at each individual laboratory and also the potential impact of final reconciliation and financial /marketing results**.**

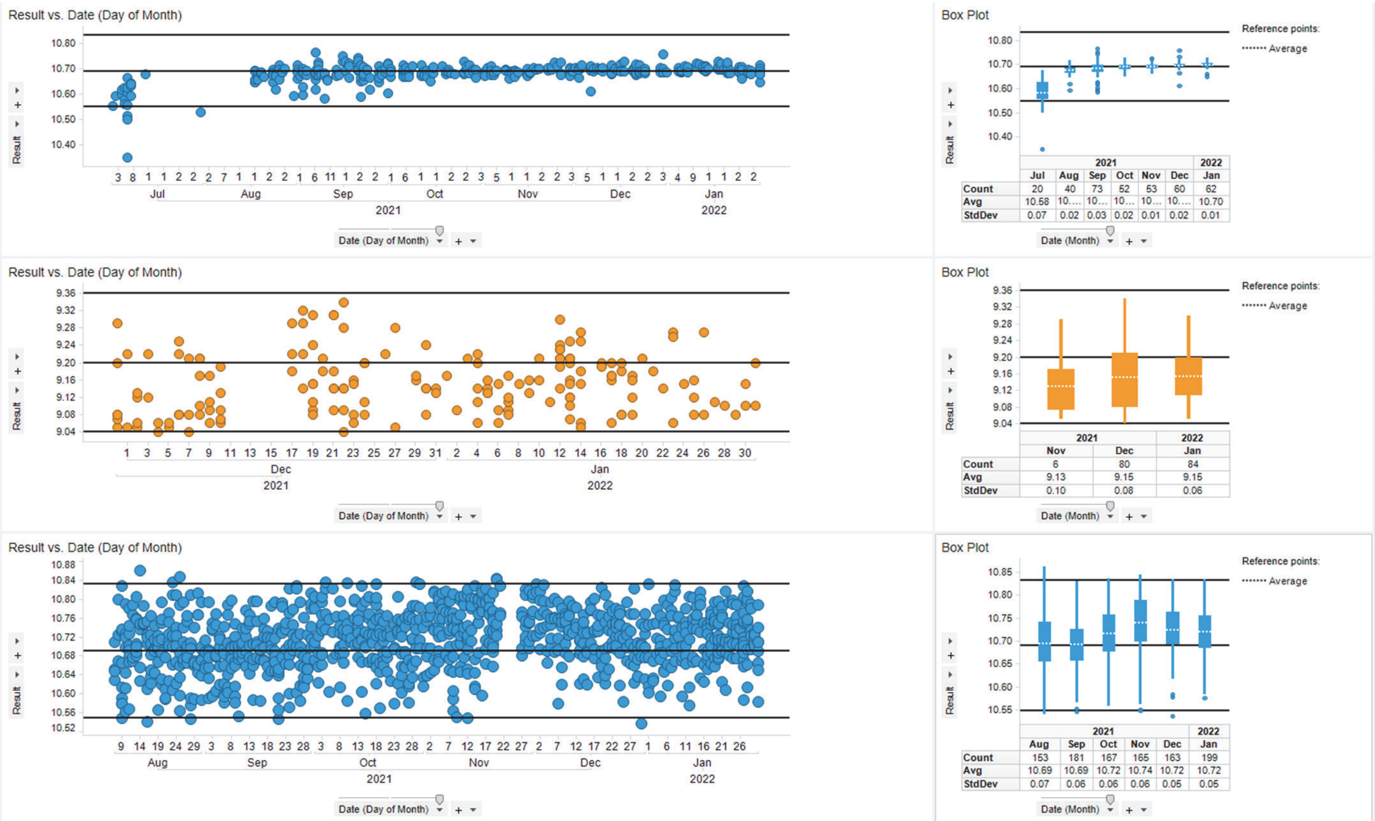

Figure 6. Daily QC run chart (difference between QC result in each assay batch and QV reference value) and monthly Box Whisker plots of QC data for 3 laboratories in the same organisations for ash.

- In addition, normal contract review meetings with laboratories can now include:
    - The review of this information in order to compare the individual laboratories within the organisation, and discussions of the outcomes of the company's review of QAQC activities conducted between meetings.
    - Benchmark individual laboratories within the same company, but also between companies.
    - The monitoring of the progress of any actions raised to address any findings raised during any of the proactive QAQC review processes described above.

Conclusion

There are many benefits for implementing a proactive QAQC and QM program. Issues that impact on the quality (precision/accuracy) of the results reported by laboratories have the potential of resulting in unplanned out of specification product, creating even more workload and stress for companies that operate in a resource constrained environment. A proactive approach on QAQC and QM in the coal industry, as described in this paper, would identify these types of accuracy and precision gaps before they become an issue.

Using a visualisation product, such as Spotfire or Power BI, significantly reduces the time it takes to create them, once the importing template database has been created.

The use of a pulverised reference material (Coal RM) is important to eliminate the potential misleading conclusions from samples that need to be prepared and analysed i.e., sampling and preparation errors are significantly minimised from the equation.

It is essential to regularly receive and review laboratory internal QC data in order to closely monitor quality. Reliance on the laboratory or leaving the review of this data to the 18 month NATA ISO 17025 accreditation audits to identify and react to emerging trends and bias is not at all proactive.

A proactive QAQC and QM program enables better inputs into the reconciliation process, emerging trends and bias are identified long before they become a problem which means better financial outcomes for port and marketing.

This paper describes the beginning of a journey, there are more milestones currently in progress to achieve an even more robust proactive approach to QAQC and QM.

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