

Optimising Alumina Production Through Advanced Process Monitoring and Alert Systems

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Abstract

Alerting systems are critical for maintaining operational excellence, providing timely notifications that enable rapid responses to potential challenges. This innovative system integrates intelligent automation with comprehensive monitoring to optimise industrial operations. The core approach combines automated task management with sophisticated data gathering. Its flexible data collection capabilities allow seamless integration of diverse information sources, creating a holistic operational overview and by automating repetitive processes, the system frees organisational resources for strategic decision-making. The system's key strengths include customised reporting that transforms raw process data into actionable insights, enhancing decision-making precision. A unique feature is the dynamic procedure attachment, which directly links relevant procedural documents to specific alerts, empowering teams to respond swiftly and confidently. Beyond merely tracking events, this comprehensive approach guarantees enhanced safety, reliability, and operational efficiency. By leveraging advanced automation and intelligent data management, the system represents a significant technological advancement in industrial monitoring, fundamentally transforming how organisations approach operational management and continuous improvement. Some of the processes monitored by our tool includes:

- Monitoring of radioactive devices as per governmental regulations.
- Tracking product quality indicators as agreed with our customers.
- Tracking the regular testing of safety devices across the refinery in line with EGA's EHS requirements.
- Monitoring high voltage critical equipment across all of refinery's substations

Keywords: Robotic process automation, Operational technology, Process information management system, Digital transformation, Alerting and events reporting.

1. Introduction

Alerting and reporting systems are indispensable tools for manufacturing industries, empowering organisations to monitor operations in real-time, maintain quality standards, optimise efficiency, ensure regulatory compliance, and drive continuous improvement. Despite being one of the most modern alumina refineries in the world, EGA's Al Taweelah alumina refinery also faced challenges with robust and efficient alerting given such a diverse range of applications and data sources that comprises the suite of solutions required to run and monitor the process. The main reason that drove the development of this tool was the need for highly customisable alerts based on process parameters which are especially dynamic on a greenfield refinery.

2. Automated Customised Reporting

The need for customised reporting emerged from the operations as a requirement to automate rule-based process condition alerts and screen capture of existing monitoring pages into scheduled

reports. As these processes matured, we expanded the scope into health alerting systems as well. You can see in Figure 1 the evolution of the Robotic Process Automation (RPA) system as we incorporated more features to it and what each block is comprised of:

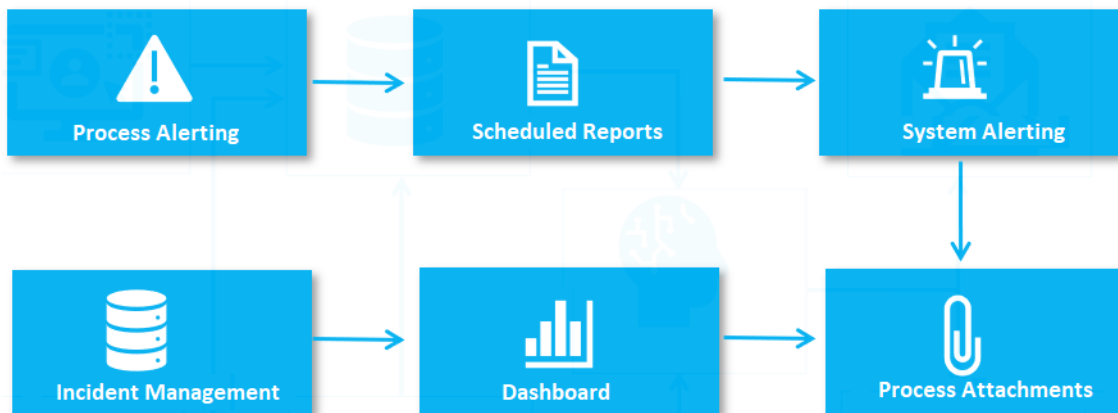


Figure 1. AI Taweelah alumina Robotic Process Automation (RPA) system.

- **Process Alerting:** Includes rules for email alerting based on process conditions and caters requirements from technical, maintenance, or production departments.
 - Inputs are from process data or process events.
- **Scheduled Reports:** Provides automated reporting based on a fixed schedule and can have dynamically built designs or take screen capture of other applications that have their own reports or system status screens.
 - Inputs are from process data, process events or web applications.
- **System Alerting:** Added alerting for the technical department to monitor the system health and react pre-emptively to issues. Allows us to bring alerting from several different systems into one place and to create custom trigger rules to map different types of issues from the same system to different alerts.
 - Inputs are from applications, Windows services, and Windows Scheduled Tasks.
- **Procedure Attachment:** Improved the system alerting by mapping the alerts to specific procedures on how to address them to optimise even further the troubleshooting and make the fix more consistent regardless of engineer.
- **Dashboards:** Provides a centralised hub for all alerts and reports with historical search capabilities. Real-time health monitoring of technical department systems with status indicators. Advanced analytics that identify failure patterns to prioritise system improvements.
- **Incident Management:** Enables an end-to-end solution for handling system failures. Allowing users to log these alerts as formal incidents, either through the web portal or by directly responding to notification emails. Each incident captures critical metadata including the affected system, model information, error types, and timestamps, creating a structured record for tracking. The platform guides incidents through a defined lifecycle from creation to resolution, enabling assignment to responsible parties, real-time status updates, and collaborative troubleshooting. The system stores all resolution details including root cause analysis and corrective actions, building an institutional knowledge base that facilitates searching through previous similar incidents to speed up troubleshooting.

2.1. Custom vs Off-the-Shelf

While numerous commercial alerting solutions exist in the marketplace we benchmarked applications such as UiPath [1] and Microsoft Power Automate [2] for task automation and ManageEngine Applications Manager [3] for system monitoring, our requirements highlighted many key areas that favoured implementing an in-house developed system. Mainly, but not limited to the fact that the specialised requirements of industrial monitoring environments demand

a level of customisation that off-the-shelf products typically cannot provide without significant compromise. The major items are described below:

- Flexible Integration:
 - Our in-house system connects smoothly with all current data sources and equipment without the compatibility issues common with commercial products. This ensures complete operational visibility without disruptive workarounds that could compromise safety or efficiency.
- Vendor Independency:
 - Developing our own system builds knowledge and skills that remain within our organisation. This internal expertise allows faster adaptation as needs change without waiting for vendor assistance, creating lasting organisational value beyond this single system.
- Long-Term Value:
 - While requiring more upfront time investment since the time to deploy has to consider a more refined data gathering phase and a full application development, our custom system eliminates ongoing licensing fees, user charges, and customisation costs. The operational efficiencies gained from perfect alignment with our dynamic requirements generate continuous returns that commercial alternatives cannot match.
- Future Development:
 - An in-house solution gives us complete control over how the system evolves. As operational needs change or new technologies emerge, we can adapt quickly without dependency on vendor roadmaps or upgrade schedules.

3. System Architecture

The system makes use of our “single source of truth” data management approach which allows us to access multiple data-sources from a single place which improves not only performance but also our flexibility on reporting while simplifying the architecture. This single source is referred to as Common Asset Model (CAM) which is based off the Asset Management concepts from ISO 55000[4] and is a place where not only the data is stored but also metadata information regarding those datapoints such as unit of measurement, number of decimals, target, and data category amongst many others. Our team ensures that the application aligns with standards like ISO 26415 [5], ISO 27001 [6] and ISO 25010 [7]

There are 2 main categories of data being fed to the system’s data source:

- Information Systems: Relates to the manufacturing systems we manage and cover a wide range of solutions such as application connectivity, data transfer and hardware failures.
- Process Data: Relates to all the operational data coming from the field through instrumentation such as flow, level, or temperature transmitters; while also including events and alarms or operator changes to set points.

There is a wide range of technologies used across the data processing flow that allows the information to be captured, processed, and displayed to the users which cover but are not limited to the following:

- CAM: A relational database on which we designed a custom structure to store and manage all the plant information.
- Historian: A database optimised for collection and storage of high volumes of real-time process data that can go as low as 1 second collection frequency.
- RPA: A set of applications that integrate and automate several tasks from capturing screenshots, evaluating system/process conditions and many others.
- Alerts: Email generated output that evaluates pre-defined rules to assess the health of the systems or processes. Evaluates the rules every 5 minutes and keeps track of the duration of the alert in minutes.

- Reports: Email generated output that provides a summary or a snapshot of other systems/applications status. The reports are also stored so that the historical events are kept and easily accessible through Dashboards.

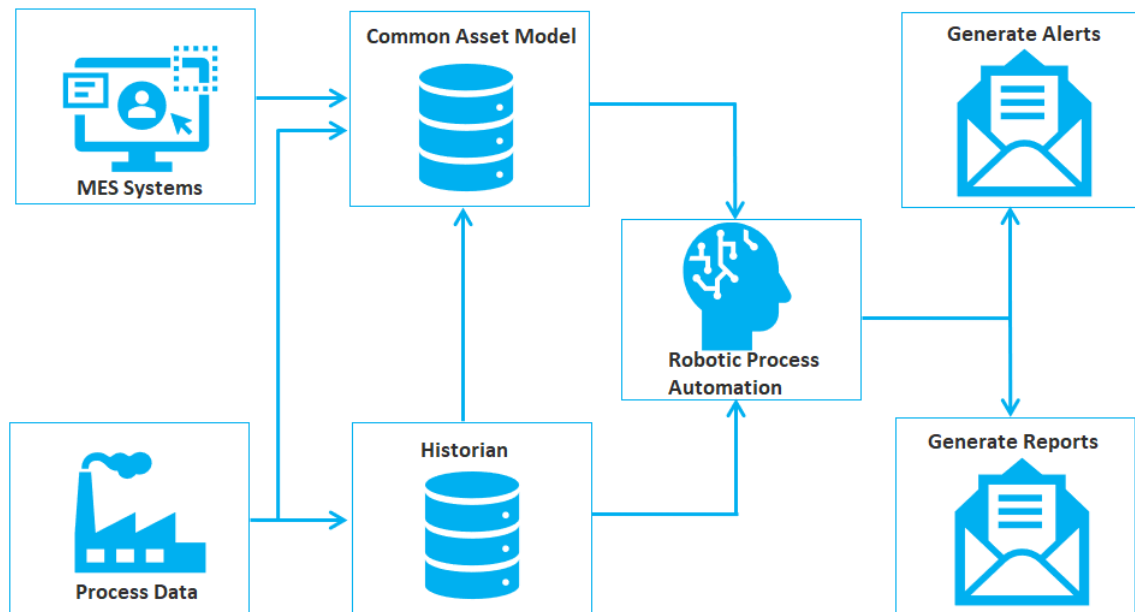


Figure 2. AI Taweelah alumina information and reporting system architecture.

4. Use Cases

This section describes some of the use cases that demonstrate how the system's architecture accommodates varied requirements while delivering measurable operational improvements with reduced implementation complexity. Overall, the system currently supports multiple departments across the refinery, such as:

- Production
- Technical
- Environment and Safety
- Maintenance
- Security

The existing use cases vary significantly; some examples are described below.

4.1 Safety Shower Reports

The Safety shower reports track operational readiness across 700+ safety shower units, ensuring compliance with mandatory monthly activation testing protocols. The system automatically generates weekly status reports identifying non-compliant units, enabling proactive intervention before regulatory deadlines are exceeded.

Each report includes comprehensive unit-specific data including location coordinates, operational status, and precise activation timestamps to support both strategic compliance management and targeted maintenance planning.

The density meter alert (see Figure 5) provides continuous surveillance of critical nuclear densitometry instrumentation, in accordance with United Arab Emirates federal regulatory requirements. It detects and reports anomalous fluctuations in radioactive measurement devices that could indicate calibration drift, source degradation, or potential contamination events.

Each detected deviation initiates a multi-departmental investigation protocol, where operations and security personnel coordinate to verify system integrity and regulatory compliance. This approach dual critical functions: ensuring adherence to national nuclear safety standards while simultaneously establishing preventive barriers against radiation safety incidents that could compromise facility personnel health or environment.

4.3 8-Flash Tank Operation

The 8-flash tank operation module continuously monitors tank configurations and alerts supervisors and management when operational transitions occur, such as switching from 9 to 8 flash tanks. The system provides real-time notification (see Figure 6) of any tank-related incidents or abnormalities, ensuring rapid response to potential issues.

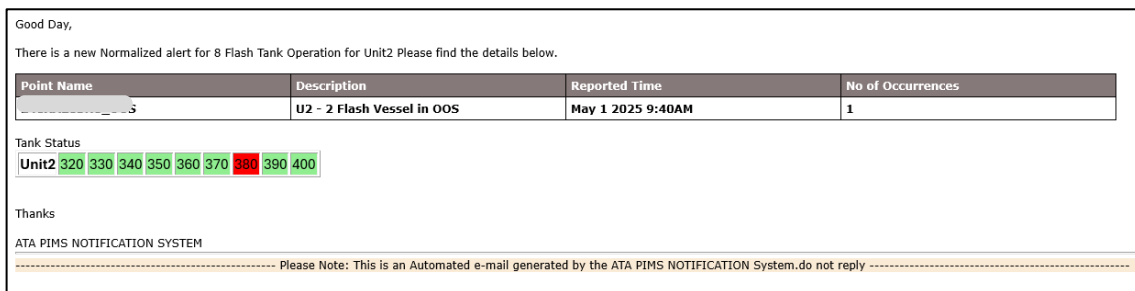


Figure 6. Normalised alert for 8-flash tank operation.

Once conditions normalise, the system automatically sends confirmation alerts to all relevant personnel, creating a complete communication loop. This ensures consistent awareness of operational status changes across shifts and management levels, eliminating communication gaps and enhancing operational safety and efficiency.

4.4 Filters Shift Handover Report

It automates shift handover by integrating with operational systems to compile comprehensive handover reports. It documents completed activities from the previous shift and identifies upcoming maintenance needs based on equipment residual life calculations (see Figure 7). This streamlined reporting enables efficient shift transitions while ensuring critical maintenance work is properly scheduled.

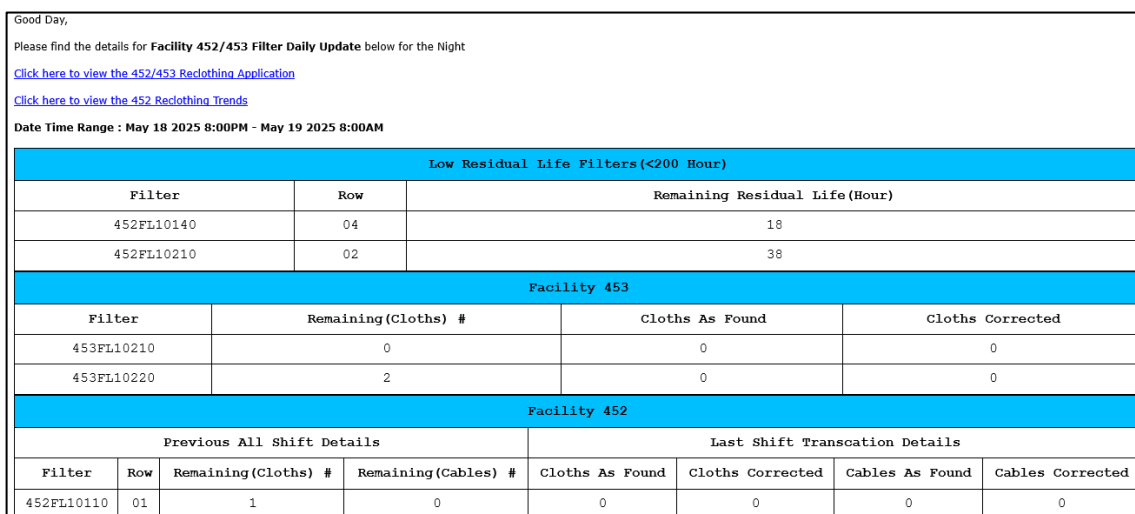


Figure 7. Filters daily update report.

4.5 Systems Events Monitoring Alert

The system events alert (see Figure 8) serves as the critical backbone of our monitoring solution, functioning as the primary interface through which all process and system data streams are collected, validated and logged. This component is essential for maintaining operational continuity, as any failure in this subsystem would compromise the detection and propagation of multiple dependent alarms.

Application	Error	Last Reported Date	Details	Frequency(min)
PHD Event Database - JA02_MN01	Error with: PHD Event Database - A02_MN01. Last reported time is Jan 7 2025 1:12PM @ Jan 7 2025 2:14PM	Jan 7 2025 1:12PM		60
PHD Event Database - JA03_MN01	Error with: PHD Event Database - A03_MN01. Last reported time is Jan 7 2025 1:10PM @ Jan 7 2025 2:14PM	Jan 7 2025 1:10PM		60
PHD Event Database - JA04_MN01	Error with: PHD Event Database - A04_MN01. Last reported time is Jan 7 2025 1:13PM @ Jan 7 2025 2:14PM	Jan 7 2025 1:13PM		60

Generic troubleshooting procedure for the above systems are attached..

Thanks

ATA PIMS MONITORING SYSTEM

----- Please Note: This is an Automated e-mail generated by the ATA PIMS MONITORING SYSTEM.do not reply -----

Figure 8. Systems events monitoring alert.

By monitoring on a minute basis, this enables near-instantaneous anomaly detection, allowing the team to initiate troubleshooting before further disruptions propagate to other alerts. This proactive approach to system health maintenance ensures data integrity and preserves optimal service levels for all stakeholders.

5. Dashboards and Analytics

The Al Taweelah alumina reports and notifications (see Figure 9) provides a self-service view to merge all the alerts/reports on a single page to facilitate navigation across reports and through time, making it easy to go back in time and check when or what data was on previously generated reports, saving the hassle of going through mailboxes and while ensuring that the data is not only available to those intended for the emailed reports but also our wider audience of Dashboard users.

S.No	Description	Unit	Value	Date
1	Refinery Production Daily	Tons		May 19 2025 11:59PM
2	Calcliner Production	Tons		May 19 2025 11:59PM
3	Alumina to EPAL	Tons		May 19 2025 11:59PM
4	Mud to truck	Tons(wet)		May 19 2025 11:59PM
5	Digestion Flow	m3/hr		May 19 2025 11:59PM
6	Precip Net Yield	g/L		May 19 2025 11:59PM
7	Hydrate Tonnage (Drums)	Tons		May 19 2025 11:59PM
8	Cauatic Consumption	Kg NaOH/t A		May 19 2025 11:59PM
9	Bauxite Consumption	Ton bix/t A		May 19 2025 11:59PM
10	Total Net Specific Energy	GJ/t A		May 19 2025 11:59PM

Figure 9. Al Taweelah alumina reports and notifications.

The Al Taweelah alumina Distributed Control System (DCS) and Process Information Management System (PIMS) Status Overview constitute a specialised dashboard made for our own department to ensure the availability of the several systems we are responsible for (see Figure 10). It provides near real-time status of the systems and includes analytics to facilitate data analysis of when/where/why the failures are happening to drive the priority of the improvements required to ensure maximum.

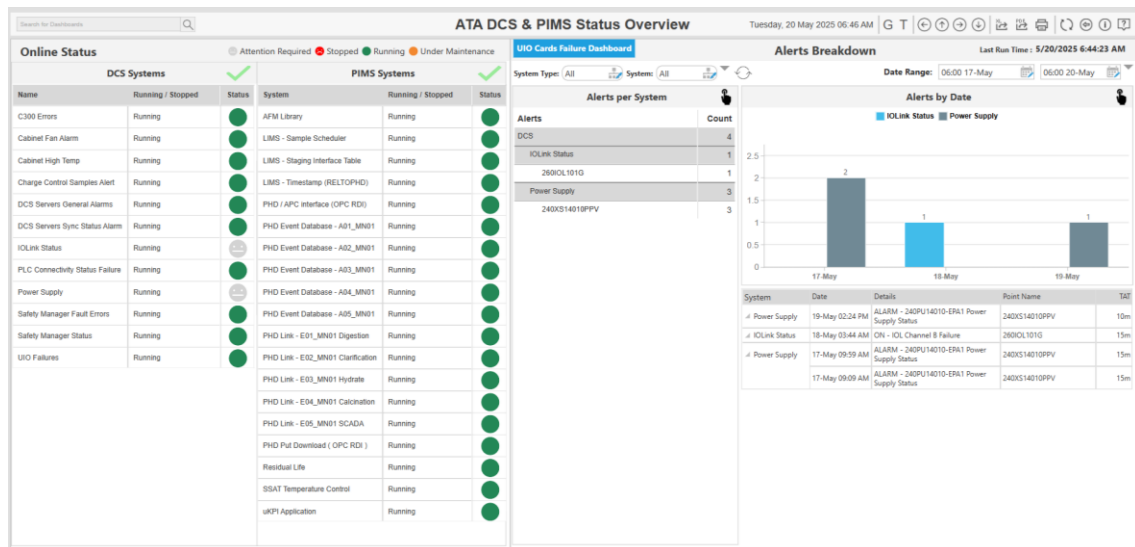


Figure 10. Al Taweelah alumina DCS and PIMS status overview dashboard.

6. Overall Benefits

The alerting system provides structured documentation of incidents and their resolution, creating a valuable knowledge base for future reference. This documentation helps organisations in several ways:

- Automatically calculates and reports the Turn-Around Time and availability metrics for each system, providing critical compliance documentation and performance visibility.
- Eliminates the need for manual system checks during non-working hours, as administrators are only alerted when specific triggers are activated, significantly reducing workload and improving work-life balance.
- Consolidates multiple data sources into a single unified interface, eliminating the need to navigate between different systems and reducing the risk of missed information.
- Provides historical trending analysis to identify recurring issues and system degradation patterns before they become critical failures.
- Enables proactive maintenance scheduling based on real-time equipment health data and residual life calculations, reducing unexpected downtime.
- Ensures consistent knowledge transfer between shifts with standardised handover reports, minimising communication gaps and human error.
- Offers customisable alert thresholds and notification routing to ensure the right personnel receive relevant information without overwhelming teams with unnecessary alerts.

7. Future Plans

Our future development roadmap leverages the extensive historical dataset we have accumulated from system alerts and process flow data to create a sophisticated predictive maintenance capability. By implementing advanced AI (Artificial Intelligence) / ML (Machine Learning) models that analyse correlations between operational conditions and subsequent failures, we aim to transform our maintenance approach from reactive to proactive. The system will continuously monitor real-time process parameters against established failure patterns, generating early warnings when conditions match those that historically preceded specific failures. These proactive notifications will provide maintenance teams with the critical lead time needed to intervene before equipment fails, while also recommending specific preventive actions based on successful historical resolutions.

The timeline for implementing these enhancements is not yet defined, as we are still focused on expanding the current scope and bringing the same level of enhanced monitoring to more applications throughout the refinery.

8. References

1. UiPath - <https://www.uipath.com/>
2. Microsoft Power Automate - <https://www.microsoft.com/en-us/power-platform/products/power-automate>
3. ManageEngine Applications Manager - https://www.manageengine.com/products/applications_manager/
4. ISO 55000, Asset Management – Vocabulary, overview and principles.
5. ISO/IEC/IEEE 26514:2022 – Systems and Software Engineering – Design and Development of Information for Users
6. ISO/IEC 27001:2022 – Information Security, Cybersecurity and Privacy Protection – Information Security Management Systems – Requirements
7. ISO/IEC 25010:2023 – Systems and Software Engineering – Systems and Software Quality Requirements and Evaluation (SQuARE) – Product Quality Model

