ASSET INTEGRITY OPTIMIZATION & MANAGEMENT FOR PROCESS INDUSTRIES

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AiOM®

WHITE PAPER

ABSTRACT

This white paper describes the importance of asset integrity optimization & management for the process industries. This concept spans throughout the asset's lifecycle involving all the departments of the organization, from top management to the on-field engineer. This paper further explains the evolution of asset integrity management from once the reactive approach of the past towards current computer-aided systematic and proactive risk-based approach. It also enlists the essential tools for preserving and enhancing the integrity of the asset, such as Risk-Based Inspection (RBI), Fitness-For-Service (FFS), Reliability Centred Maintenance (RCM), Integrity Operating Windows (IOWs), Corrosion Control Documents (CCDs) and much more. It further explains the important attributes of successful asset integrity, optimization & management program.

The ignored damage mechanisms like corrosion under insulation, temper embrittlement, hydrogen-related damages, liquid metal embrittlement, small-bore piping failures, process impurities leading to localized corrosion, design deficiency, metallurgical degradation and welding anomalies that can lead to major disasters need to be identified at an early stage. During the implementation of the AiOM® tool, it is possible to address these issues with the help of experienced metallurgical experts with a team study approach. The importance of a metallurgical expert with failure investigation and FFS experience is the key to the successful implementation of AiOM®.

The industries' stakeholders can thrive upon maximizing profits without compromising safety and meaningful spending on inspection and maintenance. To achieve the fundamental objectives, systematic third party implementation of AiOM® with identification of the damage mechanism is essential. Impartial implementation of AiOM® is a foundation to operate and maintain the plant for long-term sustainability.

01 INTRODUCTION

In today's competitive world, industries face challenges such as meeting stakeholders' expectations and relentless economic pressure irrespective of any sector. Worldwide there are concerns regarding the ageing of the current assets with the limited investment for building new plants and refurbishing the assets. Unfortunately, this scenario has resulted in operating assets beyond their original design criteria. This phenomenon is frequently known as 'sweating of the assets'.

'Sweating of Assets' results in a shorter turnaround schedule with low maintenance costs. There may be short-term gains in profitability, but inescapably there are lagging effects on reliability, which drops a percentage point or two. When this happens, reliability starts going in a downward spiral, which is very difficult to reverse without a concerted effort. And thus, installations suffer from significant unexpected failures and loss of containment despite seemingly good maintenance as well as inspection history, possessing health, safety and environmental (HSE) issues. Lastly, the goodwill of the company is affected at the national and international levels.

Besides, there are various prevailing issues in the industrial operation itself. Wherever there is a human involved, there are chances of ignorance and mistakes. A human philosophy is more of a reactive approach rather than a proactive one. Effects of reactions occur only after a much bigger incident happens in the organization. Furthermore, after the incident, there are failures in identifying the causing damage mechanisms and thus results in wrong inspection strategy, which further aggravates the problem. Thus, the role of asset integrity management has never been more crucial to the Industry.

02 NEED OF AiOM®

Asset Integrity Optimization & Management (AiOM®) is a holistic approach that spans the asset's whole life, starting from conception, design, construction, installation, commissioning, maintenance, inspection, repair to the refurbishment or retirement of the asset. AiOM® ensures that the elements that are vital for integrity such as people, system process and resources, are in place, in use and fit for purpose over the whole life cycle of the asset. Assets can be any equipment, tools or instrument or that help run the plant.

The long term implantation of AiOM® is not to focus only on the static or rotary equipment of the plant; rather, it also incorporates safety-critical protective systems, electrical equipment, civil components, Instrumentation and controlling systems, etc. It requires a multi-disciplinary cross-functional interdepartmental approach to achieve the intended goal. The core objective of asset integrity optimization & management (AiOM®) programs is to minimize downtime.

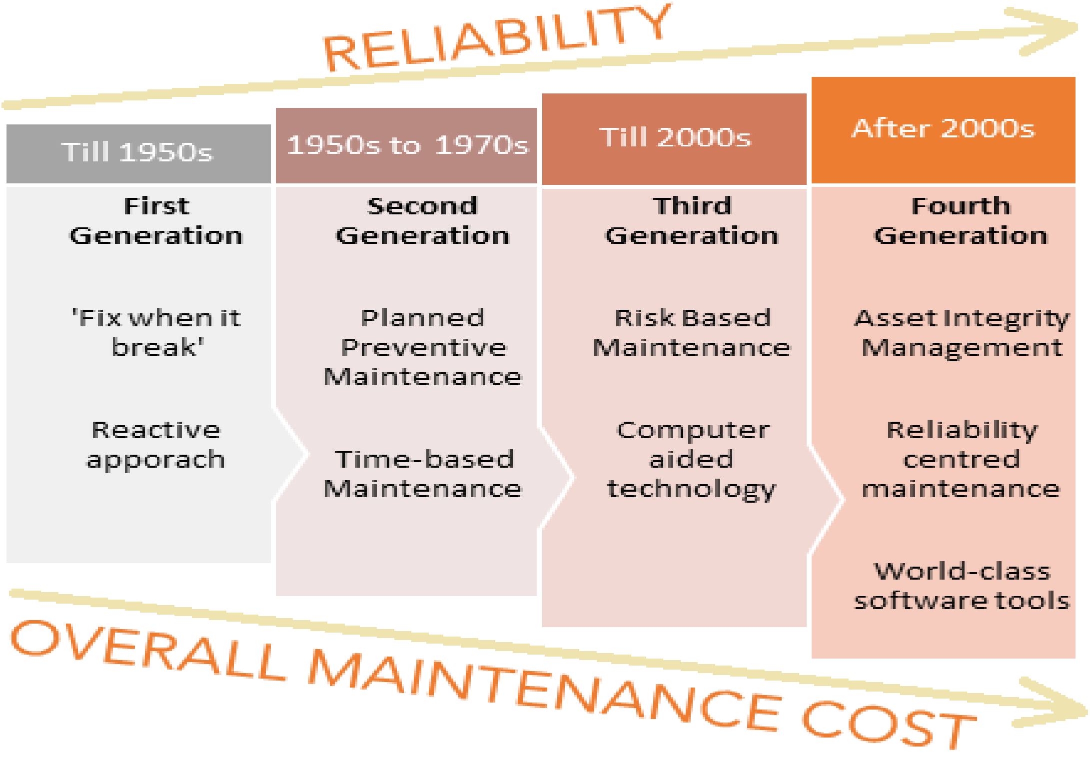
Unplanned outages can be financially exhaustive. Even planned shutdowns or turnovers can be costly and make a big difference in profitability. Often shutdowns are very complex due to dependencies and interrelated risk factors. Shutdowns cannot be avoided entirely, but it can be managed so that essential work is undertaken, risks are managed, and the impact on production is kept to what is truly is necessary. Some organizations might have documentation systems in place for keeping the maintenance and inspection history, while others might not.

Still, it is not just collecting the data on plant condition but using the data effectively for decision making and future planning. Here, AiOM® plays its part through various management strategies and tools by interfaces with other Management Systems and Programmes, such as Operation Management System, Risk Management System and HSE Management System. People and processes are at the heart of most asset integrity issues rather than fatigue cracks or corrosion. Making sure that the right people make the right decisions with access to the right information is fundamental. Inspection and maintenance processes are key to improve integrity and safety while reducing operating costs.

AiOM® is the overall change in the mind-set and culture of the organization. It is a systematic overhaul of the way companies works. In the past, multiple accidents have occurred from the cumulative effect of errors and vulnerabilities that were introduced throughout the asset's lifecycle. And there is no single pinpoint reason for the cause; instead, the whole system of operation is even-handed for the cause. It takes into consideration the effectiveness of the management system in calculation while doing risk analysis.

03 HISTORY OF AiOM®

Asset management, as a concept, had evolved in the last 60 years significantly from the reactive, 'fix it when break' idea to the proactive, 'computer-aided total asset integrity management systems'. The history of the evolution of the asset integrity optimization & management approach can be explained as described below:



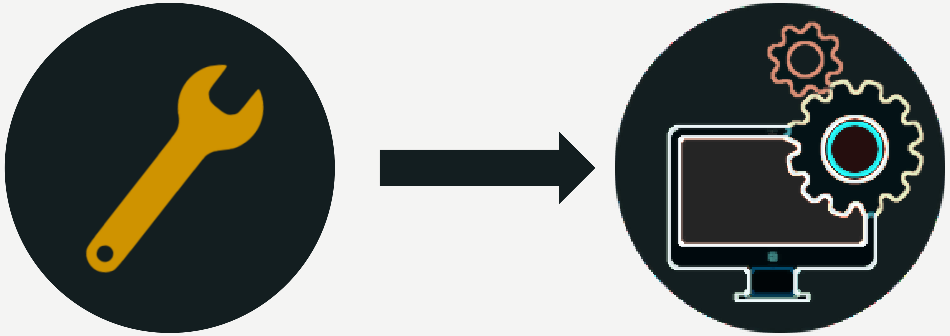
First generation (till 1950s): The idea for asset maintenance was reactive in nature. Assets were designed with keeping a high factor of safety and simplicity. Though maintenance costs were low in this type of maintenance, the cost of repair, replacement and sometimes catastrophic failure were significantly high.

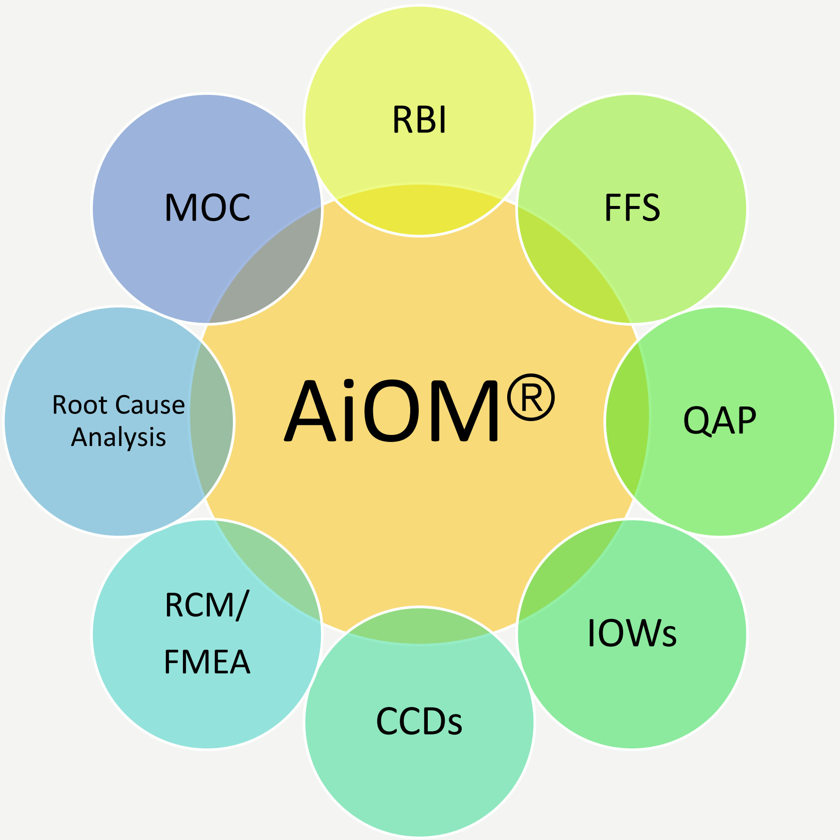
Second generation (1950s to 1970s):
Due to the increased maintenance cost, there was a need for a maintenance planning and control system. Thus, the birth of the 'preventive maintenance' concept came into existence. Plant availability and asset life improved. The mechanisation of the assets had increased.

Third generation (till 2000s):
With the advancement in computer and software technology, the 'condition-based maintenance reverted to 'time-based maintenance' giving birth to the new concept. With this came the increased cost of maintenance with increased reliability of the assets. Higher plant availability with greater safety was now possible.

Fourth generation (after 2000s):
Now, asset management as a whole package of all the mechanical, electrical, instrumentation & control systems, utility and much more is appreciated. In the design stage itself, the assets were developed for higher Reliability and lower maintenance. Newer concepts like Reliability Centred Maintenance (RCM), Failure Mode Effect Analysis (FMEA), RBI, hazard studies, and much more were developed considerably. These new mechanisms included a dynamic relationship with the production, operation, design, management teams and adopting software tools to facilitate world-class maintenance practices.

While initially the cost is high, the overall reliability of the system is much more safe and productive. There is overall shift in the organizational approach.





AiOM consists of various tools for the management of the assets such as Risk-Based Inspection (RBI), Fitness-For-Service (FFS), Reliability Centred Maintenance (RCM), Integrity Operating Windows (IOWs), Quality Assurance (QA) Plans, etc. These tools are developed by various internationally recognized institutions such as API, ASME, SAE, etc. and are widely used all over the world.

04 AiOM® TOOLS

These tools assist the reliable operation of the asset for its intended purpose safely throughout its designed life and beyond. If these tools are used rightly, they can assist in operating the asset with minimum maintenance and inspection costs with the highest efficiency. Brief description of each tool is explained below:

A) Risk-Based Inspection (RBI):

It is categorized the assets depending on their risk level. The risk is calculated based on the probability of failure (POF) and the consequence of failure (COF) of the asset. The POF can be found out based on the expected as well as recurring damage mechanisms and their severity based on the inspection effectiveness. In contrast, COF calculation is based on the amount of release of containment, the rate of release, and the effects of the release. It can be calculated based on whether the contained fluid is flammable or toxic or non-flammable, non-toxic, how much personnel injury occurred due to the release, and financial consequences (depends on the production loss, environment clean-up costs, repair and replacement costs).

The intention of carrying out the RBI is to categorise the assets based on their risk level. Based on this Risk matrix and ISO-risk plot can be prepared. And thus, more time and resources can be focussed on high-risk assets rather than assets having low-risk levels. The detailed guidelines to carry out the RBI is provided in API 580/581, DNV-RP-101 and PAS 55 standards.

B) Fitness-For-Service (FFS):

FFS of the equipment is carried out to determine if the asset in its present condition can be operated safely for future operation, sometimes beyond its designed life. API 579-1/ASME FFS-1 and BS 7910 are vastly preferred standards to carry out the FFS assessments. These standards contain quantitative calculations for generally occurred damage mechanisms in the process industry. It helps the plant managers to take appropriate decisions regarding - whether to run the equipment in its present condition or repair the flaws or retire from the service.

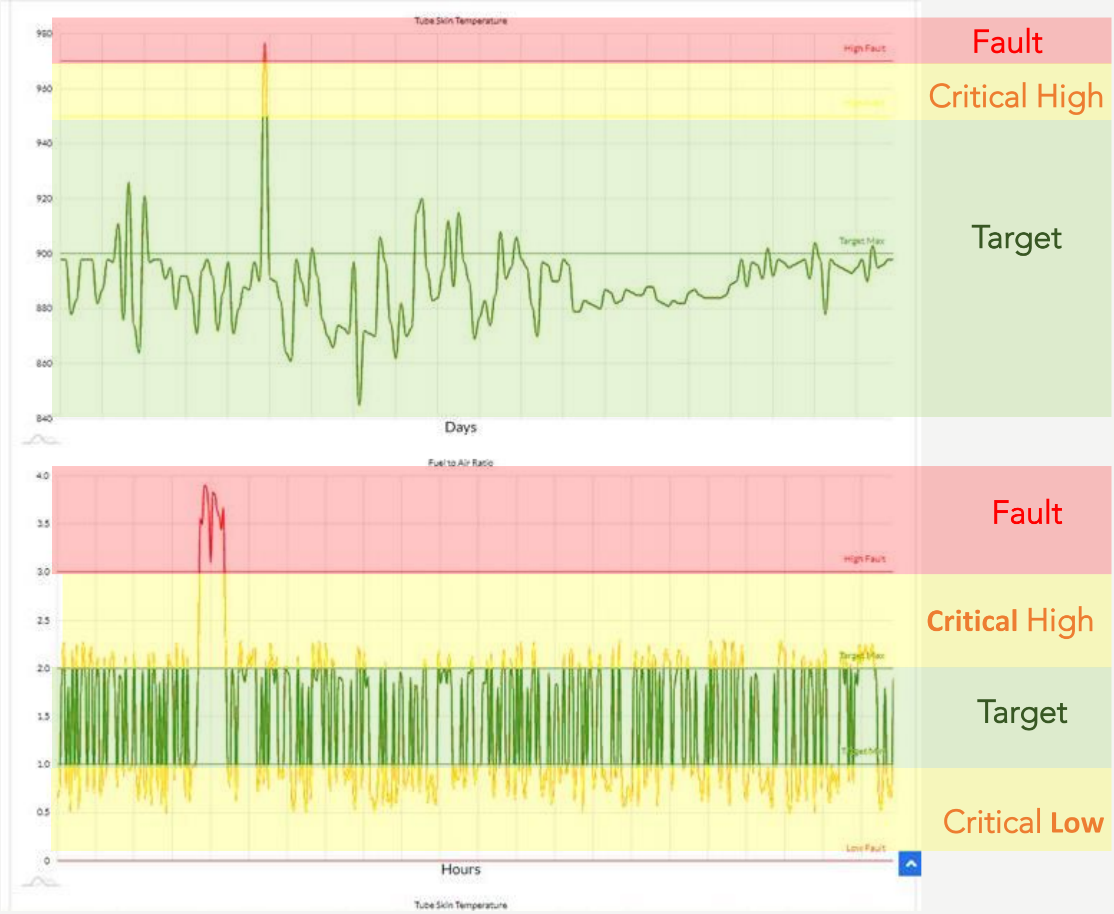
C) Reliability Centred Maintenance (RCM):

This tool is focused on running the asset for its intended life reliably, efficiently and cost-effectively. Comprehensive analysis is carried out of all the possible scenarios of various expected failures, their causes, remedies as well as their risk ranking. And thus plant operators are ready for any eventual scenarios in case of a failure. Thus it can be averted or limited in their negative effects.

This tool can be used for any static, rotary equipment as well as for instrumentation & control systems, electrical systems, structural components, etc. SAE JA-1011/1012 provides detailed step-by-step procedure to carry out the successful RCM analysis.

D) Integrity Operating Windows (IOWs):

These tools observed whether the critical process parameters of the assets stay within the defined limits or exceeds them. When they exceed the limits for a reasonable time, it instantly alarms the respective personnel about it. Thus, the degradation of the asset can be limited promptly. This data can be helpful while carrying out the inspection planning as well as during RBI analysis. API 584 provides detailed guidelines to prepare and put in place the IOWs and related alert mechanisms.



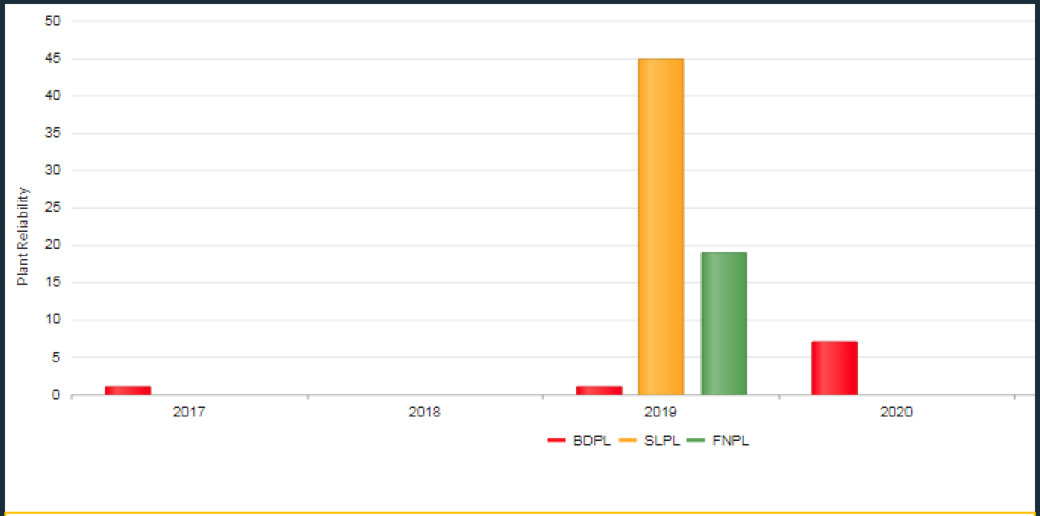
Integrity Operating Windows (IOW)

E) Corrosion Controlled Documents (CCDs):

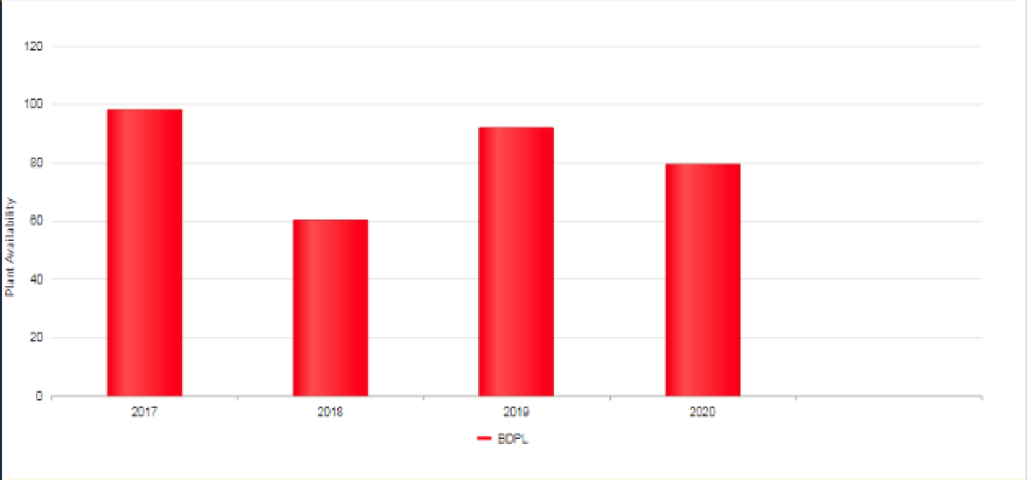
CCDs is prepared to collect all the degradation and corrosion-related data so that documents are in one place, which helps in proper inspection while planning. It is a multi-disciplinary activity consist of inspection, maintenance, design, operation, safety department, contractors, and much more in one place. It is one of the initial steps of developing the risk-based inspection system in the organization. API 970 provides the step by step procedure to create CCDs for a loop or a whole system based on their similar process parameters.

F) Management of Change (MOC):

In the organization, there needs to be proper MOC in place for the plant changes suitably risk assessed and approved before installation. This will ensure any changes will be given prior thought process before offering it for implementation. An AIMS system also takes into consideration the average time taken to fully implement a recommendation once approved and thus have a check on the management system as well.



Year wise Break down/Slow down with Production loss

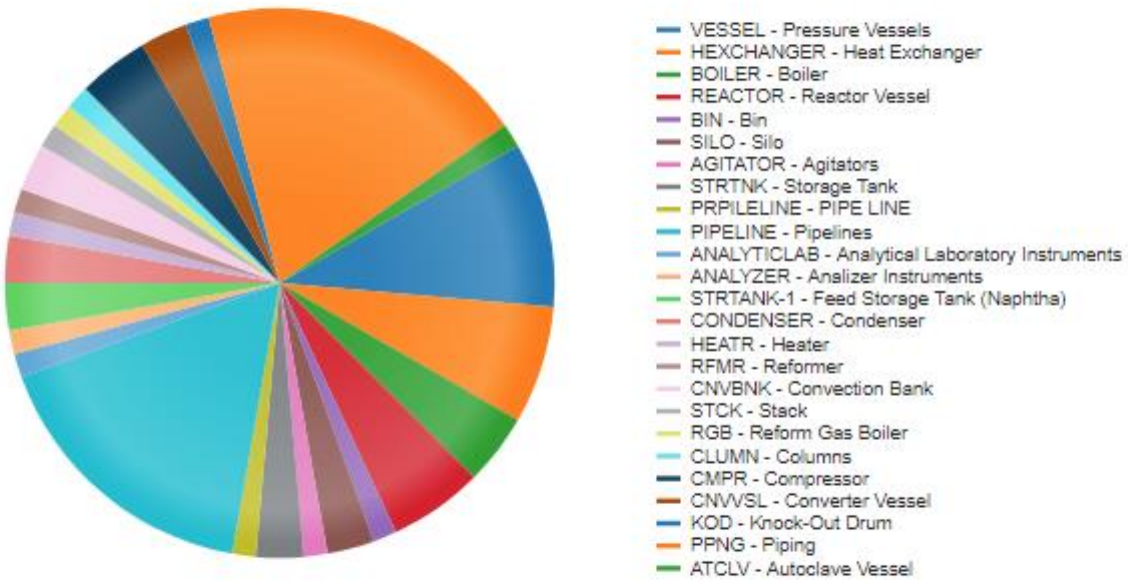


Year wise Break down hours

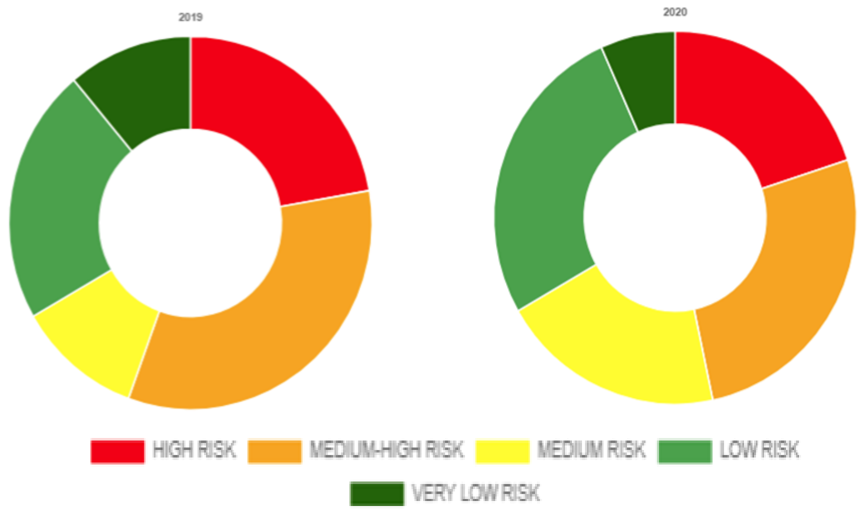
G) Quality Assurance (QA) plans:

QA plans can be helpful in every step of the asset, whether it be construction, installation, quality checks or inspection. It provides step-by-step guidelines to cover all the crucial steps that require proper quality assurance from the Third-party Inspector (TPI), manufacturer or owner/user of the asset. This will ensure that every quality check is adequately performed by authorized personnel, and any offset can be recorded.

Classification of Equipment



Year wise Risk analysis



H) Root Cause Analysis:

Failure analysis by material/corrosion experts will reveal the actual reason for the event or failure. This detailed analysis will help prevent future repetitions of such events. Also, it guides the owner/user about faulty designs or material selection. Various ASTM and ASM specifications provide the approaches to find out the actual cause of failure.

05 ATTRIBUTES OF SUCCESSFUL AiOM®

Decision-makers worldwide realise that the best way to protect their employees and equipment while saving both money and the environment is to reassess and automate their work management processes and procedures and manage them with an integrated asset lifecycle management solution. There are various AiOM® systems available in the market. But a reasonably good asset integrity management system should have the following features:

1. **Key-Performance Indicators (KPI):**

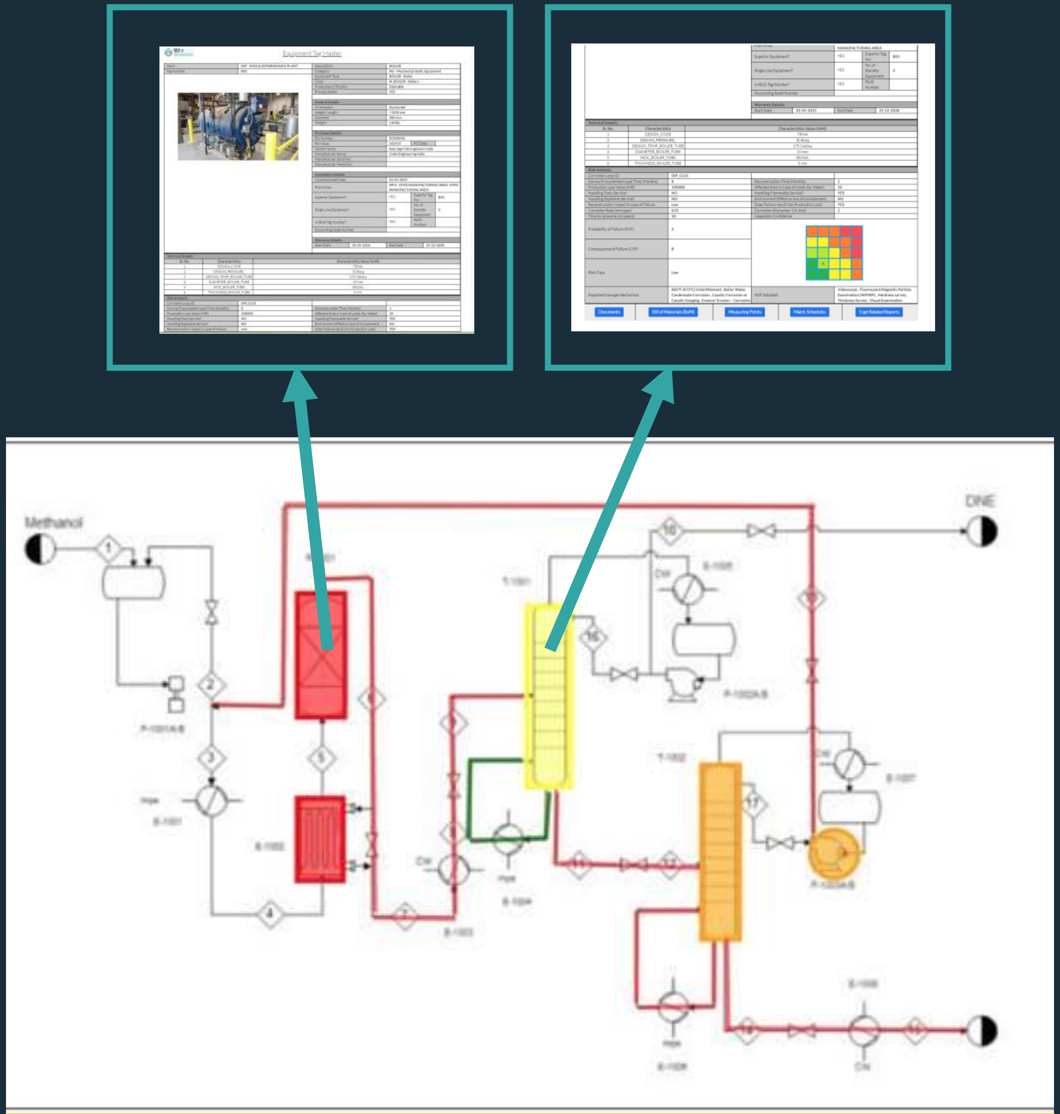
It should reflect in real-time the key-performance indicators of the asset. This is helpful generally for top management to have a birds-eye view of the plant. Also, it is beneficial for the managers or planners to get an idea of where to focus their attention to improve the system's performance. Also, by alerts & notification, the management/senior engineer knows the information about any process exceedances in real-time.

2. Digitization of documents:

Making a system where entire data integrates on a single platform helps to digitize the documents so that it can be accessed anytime from anywhere. This is helpful for industries that do not have proper documentation systems and still rely on paperwork. It is useful in maintaining a record of the activity carried out in the organization such that it can become a guiding tool for future operations.

3. Records of the Plant Bad Actors:

The systems should show the management which assets consume more resources and have longer turnaround times and thus lower productive timings (Bad actors). So that decision on them can be taken judiciously, and therefore respective measures can be taken to improve the efficiency and reliability of the system. It can be helpful for the management to identify which contractor company’s system is creating repetitive failures and thus less dependable.



Intelligent P&ID

"The truth is that Teamwork is at the heart of Great Achievement"

John C. Maxwell

4. User-friendly:
The system should be more user-friendly and easy to operate, rather complicated and erratic. It should easily integrate with the current ERP system of the organization (if any) (customization) and be auditable in nature.

5. Inventory management:
The system should contain all the information on the spares/materials used in the plant. It will help the plant managers to assist when to order the spares. And thus, the cost of additional spares accumulation can be optimized.

6. Inspection schedules:
The system should have all the information about inspection schedules of all the equipment and thus notify whenever any deadline of inspection is missed of the critical components. This schedule comprises all the preventive & predictive maintenance, look-listen-feel (LLF) rounds, turnaround schedules, risk-based inspection schedules, and any regulatory requirements. It may also suggest the checklist which needs to be cover during the inspection exercise.

06 IGNORED ASSET DAMAGE MECHANISMS LEADING TO DISASTER

Often in industrial plants, damage mechanisms are tough to locate and identify. Many times engineers do not have convenient knowledge about the occurring degradations. Thus, the inspection is not carried out effectively, or wrong inspection techniques are chosen, which leads to tragic accidents and disasters.

A) Corrosion under insulation (CUI):

Many vessels and pipelines are insulated to stop the thermal losses. But if there is any discontinuity in this insulation, there are chances of water ingress from this location. Suppose the fluid temperature in the component is not high enough, and the construction material is of carbon steel, low alloy steel, austenitic stainless steel or duplex stainless steel. In that case, there are chances of water trapped under the insulation. This causes localised corrosion at those locations. The main issue with this type of damage is that the outside insulation looks satisfactory, and the operator assumes no degradation at that location. And thus, it is generally ignored.

"In the age of information, ignorance is the choice"

Donald Millar

Corrosion under insulation (CUI)

This type of damage can be inspected by thermography or neutron-backscatter technique non-intrusively. This can also be inspected by removing some portion of the insulation and getting ultrasonic scanning or radiography to get the overall picture. There are chances that the removed portion might not be the actual representative of the damage.

Small bore piping failure

Failed Hose Pipe

“Failure is success in process”
Albert Einstein

B) Small bore piping failure:

Small-bore piping generally refers to piping having a diameter less than 2 inches attachments to vessels. Some main process piping are temperature/ pressure sensors, piping connected to compressors & pumps, instrumentation lines, site glasses, pressure safety valves, blowdown lines, drain or vent lines, etc. These lines have very high vibrations due to various reasons such as misalignment, error during fabrication, variable speed equipment, etc.

This sometimes causes unexpected failure or rupture, which causes volatile/poisonous release of gas or liquid and damage to machinery. The problem magnifies as there is not a fool proof inspection system available in the market.

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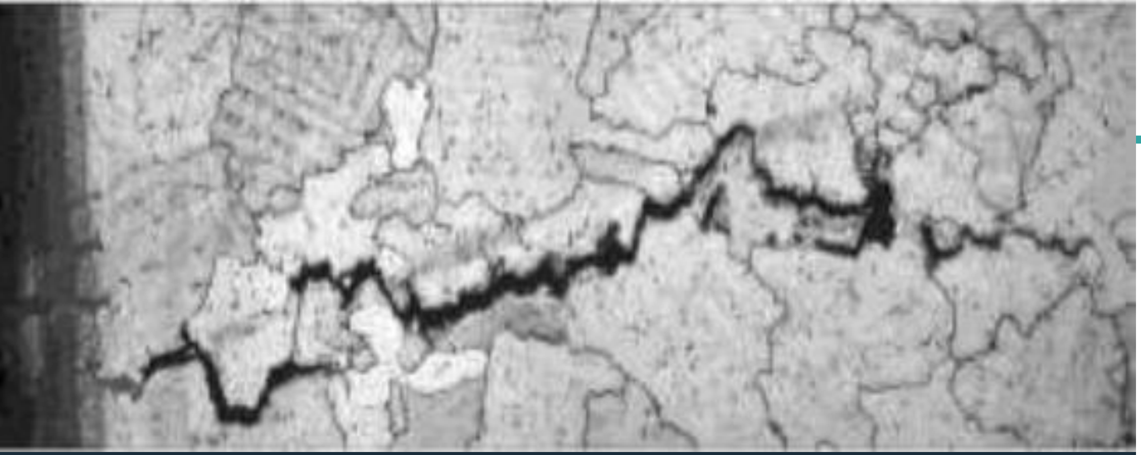

The above image shows a panoramic view of the crack initiated from an edge over the protective coating and propagated across the grains in intergranular mode on a 1st stage bucket of 10MW gas turbine.

C) Metallurgical degradations:
(Change in metallurgical properties over its lifetime)

In the asset's life span, the metallurgical changes occur depending on the type of material used when the process parameters are applied, due to any unwanted excursions during the pressure testing and various other reasons. Temper embrittlement, hydrogen-related damages, and liquid metal embrittlement can lead to major disasters that must be identified in the early stage. It results in changes in the microstructures of the material, which can be catastrophic in nature if not identified in time.

The micro-cracks that are initiated needs to be determined by in-situ replication technique as well as using advanced NDT methods. However, the proper interpretation of the results also requires expertise. The material database and susceptibility of the temper embrittlement may be identified for early detection.

07 ROLE OF METALLURGICAL EXPERT FOR ASSET INTEGRITY

The knowledge of current health of the asset is the most crucial part of the asset integrity optimization & management program. This information is vital for the appropriate planning of maintenance and inspection activity and in a way for increasing the productive life of the asset. The engineers who prepare the schedule and techniques for the inspection often lack knowledge about the damage mechanisms which affects that particular equipment depending on its process parameters. Here, the metallurgical expert who has extensive knowledge about the degradation mechanisms can be beneficial. The concerned person can accurately predict the condition of the asset much more extensively.

In addition, the involvement of the metallurgical professional in the preparation of various asset integrity tools such as CCDs, Reliability study reports, Root cause analysis, IOWs, etc., can be valuable.

There are often instances where unusually high wall loss or corrosion is observed during the inspection. Here, the corrosion/material expert is needed to know the cause and the future action plan.

Overall, their knowledge can be precious throughout the asset's life cycle, i.e. from the material selection during the initial designing phase to the proper decommissioning/ retirement of the asset.

08 OUR APPROACH TO IMPLEMENT AiOM®

Implementation of AiOM® includes following major activities:

- ✓ Preliminary Joint meeting for understanding the objective of the organization regarding asset integrity management.
- ✓ Collection of engineering data, drawings and process details.
- ✓ Detailed analysis of collected data.
- ✓ Review history of failures.
- ✓ Training to personnel involved in the AiOM implementation
- ✓ Risk-based assessment by team study which includes personnel from different departments such as inspection, maintenance, operation, design and TCR experts
- ✓ Design Check & verification if necessary
- ✓ Development of maintenance and inspection strategy
- ✓ Identification of corrosion loops
- ✓ Identification of applicable damage mechanisms and failure modes

- ✓ Review of existing inspection schedules & follow-up activities
- ✓ Optimizing inspection interval based on comprehensive study
- ✓ Implementation of IOW & CCDs.
- ✓ Implementation of AiOM® Tool to build an organizational culture
- ✓ Monitoring
- ✓ TCR support for corrosion management, inspection, root cause analysis, Fitness for Service, Remaining Life Assessment etc.

09 BENEFITS OF AiOM®

The advantages of asset integrity optimization & management are quite clear:

- ✓ Optimization of inspection and maintenance resources
- ✓ Minimization of downtime and planned outages
- ✓ Loss prevention
- ✓ Compliance with regulations and industry standards
- ✓ Mitigation of health, safety, and environmental exposures
- ✓ Proper documentation for Maintenance & Inspection data preservation for future retrievals
- ✓ Continuous monitoring of critical process parameters and instant emergency response
- ✓ Establishment of a single objective oriented working environment

Ensuring you have the information you need to prove that your assets are safe to operate.

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OPTIMIZING ASSET INTEGRITY

A Global Leader in Industrial Asset Integrity Management

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