

Ivara EXP Supports INPO AP-913

The Equipment Reliability Process Description, INPO AP-913, assists INPO member utilities in maintaining high levels of safe and reliable plant operation in an efficient manner. This business process integrates and coordinates a broad range of equipment reliability activities to:

- Evaluate important station equipment
- Develop & implement long-term equipment health plans
- Monitor equipment performance and condition, and
- Make continuing adjustments/improvements to the maintenance program

Striving for excellence in equipment performance is an ongoing goal in maintenance and reliability engineering organizations. Ivara EXP is an innovative software solution to aid these organizations in complying with the process guidelines of INPO AP-913.

The management of equipment performance is integral to business success in nuclear utilities. Asset reliability mitigates safety-related accidents and plant shut down.

The key to managing equipment performance is to manage the business process required to produce the desired results. The Equipment Reliability Process is an integral part of a much larger business process responsible for managing the total enterprise.

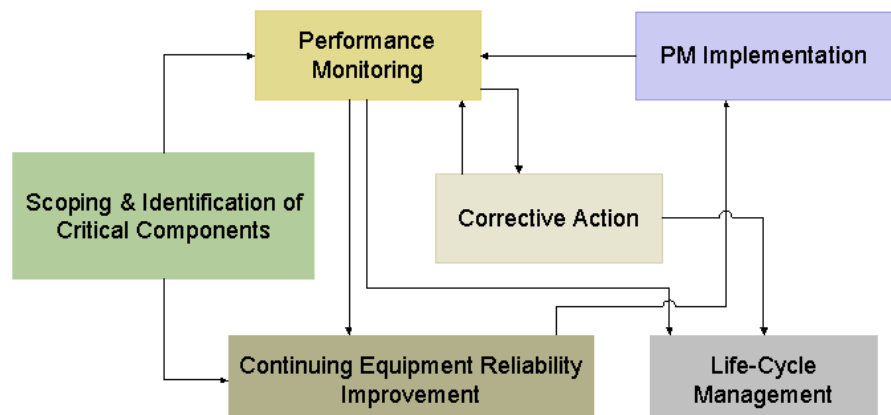


Figure 1- INPO AP-913 Equipment Reliability Process

Ivara EXP automates each step of the Equipment Reliability Process allowing nuclear utilities to become

more efficient and effective in maximizing the reliability of plant systems, structures and components (SSC's) and balancing costs. Now more than ever, with shrinking budgets and fewer resources, maintenance requires innovative solutions to maximize equipment reliability while optimizing cost efficiencies.

Maximizing equipment reliability within manageable costs is not easy. Maintenance organizations in the power industry are faced with many challenges amidst restructuring and consolidation. Business models are changing. Where price was once determined by cost plus profit, today, profit is determined by a set price less costs. So, cost management has a direct impact on profitability. Power plants are now taking drastic cost-cutting measures, like reducing engineering staff by 10 – 25%, forcing maintenance and reliability organizations to do more with less. At the same time, many companies are struggling to capture the enormous amount of knowledge lost as experienced maintenance workers retire.

Leading companies are deploying advanced reliability technology to support a proactive, condition-based approach maintenance. Ivara EXP reliability software supports proactive, condition-based maintenance and captures the asset reliability program knowledge of maintenance and reliability experts in short supply in power plants today.

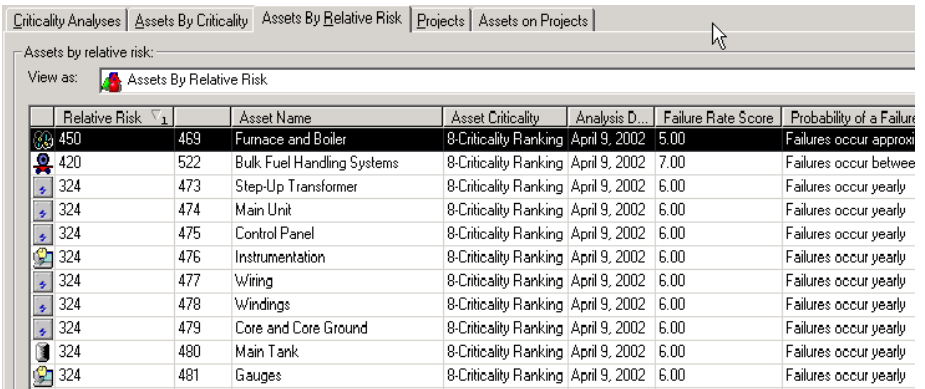
Scoping & Identification of Critical Equipment

Scoping & Identification of Critical Components

The Equipment Reliability Process, AP-913, states that *the scoping and identification of critical systems, structures, and components (SSCs) should be an integrated activity that is a common input to continuing equipment reliability improvement and establishing equipment performance criteria.*

The Criticality module in Ivvara EXP provides a systematic approach to determine how important an asset is to maintaining safety, reliability, and power generation. Ivvara EXP assesses potential impact of asset failure based on criteria you define, such as:

- safe shutdown, safety-related and essential nonsafety-related functions
- Maintenance Rule functional failure
- license renewal scoping, including passive functions
- necessity to power generation
- environmental qualification (EQ)
- station blackout
- fire protection
- anticipated transient without scram
- pressurized thermal shock (PWRs)



Relative Risk	Asset ID	Asset Name	Asset Criticality	Analysis Date	Failure Rate Score	Probability of a Failure
450	469	Furnace and Boiler	8-Criticality Ranking	April 9, 2002	5.00	Failures occur approx
420	522	Bulk Fuel Handling Systems	8-Criticality Ranking	April 9, 2002	7.00	Failures occur between
324	473	Step-Up Transformer	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	474	Main Unit	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	475	Control Panel	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	476	Instrumentation	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	477	Wiring	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	478	Windings	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	479	Core and Core Ground	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	480	Main Tank	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly
324	481	Gauges	8-Criticality Ranking	April 9, 2002	6.00	Failures occur yearly

Figure 2: Criticality Analysis in Ivvara EXP

Using EXP software, you tailor the criteria based on your specific needs.

Understanding Failure Consequences and Probability of Failure are Key

Ivvara EXP's systematic approach ensures consistency in assessing criticality of your structures, systems and components. It identifies those components that both matter most when they fail and that fail the most.

For each criticality assessment criteria, the potential failure consequences and the probability of failure are identified. The result of the analysis performed by Ivvara EXP is a relative risk number used to identify candidates for asset reliability improvement. Continuous equipment performance improvement activities are prioritized based on the criticality assessment.

Defining the proper asset reliability program (the right work at the right time) for critical assets will take priority over non-critical components, which may be left to routine preventive maintenance or left to run-to-failure. For non-critical components, criteria such as history of unacceptably high repair, replacement, or operational cost; operator or maintenance burden, expense to repair or replace, lead time for replacement parts may be considered in determining the action to take.

Lastly, INPO AP-913 requires that the classification of each component for common input to performance monitoring be documented and readily accessible to system and component engineers. In Ivvara EXP, equipment can be sorted by classification and criticality. Ivvara's Indicator Panel allows you to monitor alarms triggered by the condition of the equipment. Alarms are sorted by severity and take into consideration the criticality of the equipment. EXP goes one step further to automatically notify Engineers of alarms via email or pager as soon as the asset condition triggers an alarm. Maintenance work requests generated from alarms reference the specific condition and the critical nature of the asset so craft personnel are informed of the importance of the components they are working on. The trace-ability of events and triggers is made easy in Ivvara EXP, allowing for reconstruction of events to support decisions made.

Equipment Performance Monitoring

Performance Monitoring

Ivara EXP is an enterprise system to help you track the performance of your equipment. It also supports the creation of Health Reports, providing regulatory bodies with the information needed to prove the reliability of your critical systems, structures, and components.

To improve reliability, nuclear organizations are using a variety of tools including predictive maintenance technologies such as oil and vibration analysis and infrared thermography. However, it has been very difficult to analyze, correlate and act on this data in a timely and effective manner.

Condition monitoring alone is diminished in value if the data is not utilized to trigger the right work at the right time. These condition-monitoring activities generate massive amounts of data related to the health of the equipment. To be of real value, the data must be effectively analyzed, compared against defined "normal" states and then the analysis must be communicated.

Proper management of condition and state information ensures timely corrective action is performed to minimize failure consequence. Effectively done, this management of condition information leads to continuous improvements in asset reliability.

Ivara EXP helps you manage this data, a task that could not be done manually – thereby increasing the efficiency of the nuclear site's compliance with AP-913.

Ivara EXP collects, stores, displays, analyzes and manages all asset condition and maintenance program information.

Ivara EXP collects equipment condition data from visual inspections, predictive maintenance technologies, controls, sensors, and data historians. EXP consolidates and analyzes all condition data, identifies potential failures and recommends corrective actions. The results are presented visually through flashing alarms and trending graphs.

EXP stores your recommended corrective



Figure 3: Flashing alarm in Ivara EXP is triggered by built-in rule and calculation (inset).

actions for specific functional failures. When a condition triggers an alarm, the alarm is acknowledged and a work order can be triggered in the Computerized Maintenance Management System (CMMS) based on the recommended action. With Ivara EXP, maintenance decisions are made based on asset health and risk to the business (asset criticality). EXP identifies the right work at the right time, so you can optimize asset performance and extend asset life.

Corrective Action

Corrective Action

Modern equipment is now so complex and the consequences of failure are so serious that it is no longer possible to develop viable physical asset management strategies using traditional approaches. An array of proven analytical techniques and management processes are now available to deal systematically with the most pressing issues confronting the managers of physical assets. Many of these techniques overlap and therefore need to be applied in a coherent and efficient manner.

Upfront work identification to build an asset's maintenance program is the foundation of the equipment reliability process. Different strategies can be used to define or refine the maintenance program for equipment. These may include the application of Reliability-centred Maintenance (RCM), the application of Predictive Maintenance Needs Assessments, and the use of preventive maintenance optimization techniques, failure analysis techniques and the application of maintenance task analysis. The key to success is to look for the solution with the lowest resource intensity promising to deliver the highest equipment reliability performance.

RCM2 is the most rigorous and precise form of work identification. RCM2 combines the most valid analytical techniques into a single framework which incorporates techniques like FMEA (failure mode and effects analysis) and RCA (root cause analysis) to identify problems – and then provides a formidable decision-making process for making the right choices from the full range of failure management options for dealing with each problem. It provides precise and highly focused criteria for deciding whether it is worth investing in new maintenance technologies such as CBM (condition-based maintenance), and if so for deciding how often the associated tasks should be done.

RCM2 goes far beyond hazard analysis techniques like HAZOP in making risk management an integral part of asset management, from the viewpoints of design validation, human error and deterioration. It is especially powerful in dealing with complex new technologies which embody high levels of protection. Above all, RCM2 enables managers of physical assets to make the right choices – RCM2 is a process that has rapidly become as fundamental to the practice of physical asset management as double-entry bookkeeping is to financial asset management.

Since there is a many-to-many relationship between the proactive tasks and the many failure modes discovered in a typical RCM, the result of an RCM analysis can leave you frustrated with the daunting task

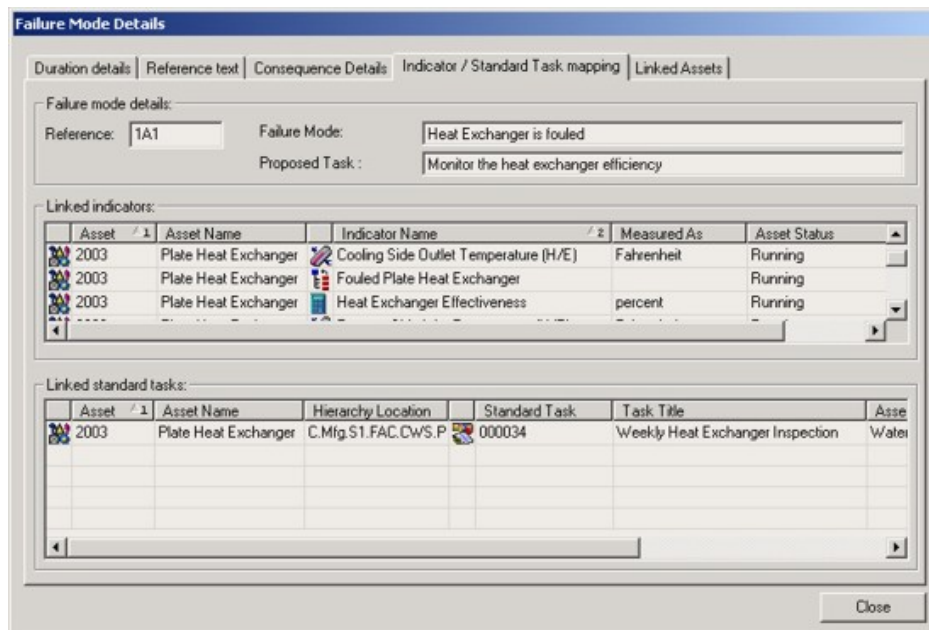


Figure 4: The value of RCM lies in the actions you take based on the analyses.

of converting the RCM to an automated asset reliability program - there just aren't enough human resources to do it manually.

The value of RCM lies in the actions you take based on the analyses. EXP is the only system available that computerizes the output of the RCM analysis, making the RCM investment an applied RCM. With EXP, an RCM analysis can be implemented in one tenth the time required to implement manually.

Ivara EXP allows you to easily implement RCM findings – so the results are not sitting in a binder on a shelf. Ivara EXP links the results of the RCM2 analysis to the asset on which the analysis was performed. Proactive tasks as well as condition and state-based indicators recommended from RCM2 analysis (or other structured work identification methodologies) are incorporated into the asset reliability program so that when a functional failure is impending, EXP presents the results visually as flashing alarms and recommends action based on the knowledge it has captured from your reliability engineers.

While applying RCM2 to your most critical assets, Ivara's less structured Maintenance Task Analysis can be used to quickly build or enhance your asset reliability program for all assets across the plant. The Maintenance Task Analysis leverages historical and readily available knowledge pertaining to the maintenance of the asset. This knowledge may evolve from the existing maintenance program, vendor recommendations or the experience of your trades people and operators.

Continuing Equipment Reliability Improvement

Creation and use of templates is recommended by INPO AP-913. Creating maintenance programs on like assets will save you time and money. Ivara's proactive maintenance task template library includes templates for all types of work including:

- Tasks that check if something has failed (as in protective devices)
- Tasks that check if something is failing (condition monitoring where there is some deterioration and degradation in performance)
- Tasks that are scheduled restorations or replacements

Many complex engineering calculations and algorithms are built into condition indicator templates provided with Ivara EXP. Others can be built quickly using Ivara's easy-to-use tool.

AP-913 also recommends continual adjustments to optimize tasks & frequencies. In Ivara EXP, users create templates and keep tasks up-to-date by pushing changes from the template to the specific tasks created for the equipment.

Ongoing evaluation of unexpected failures helps nuclear operations to understand why a failure occurred and what process should have prevented it instead of just repairing it. When you set up your asset reliability programs in Ivara EXP, continuous review of the maintenance program becomes a natural part of the process. With complete online access to all of your failure analyses, you will increase the effectiveness of maintenance by providing a tool that supports a proactive maintenance strategy.

Life-cycle Management

Optimizing the operation, maintenance, and service life of SSCs is an important part of the long-term equipment reliability strategy for nuclear plants. Maintenance goals must be aligned with Station Business goals in order to improve bottom-line performance and gain a competitive advantage. Criticality assessments help focus the organization on the assets which are at highest risk to the station.

INPO AP-913 states that nuclear plants should assess asset health & vulnerabilities and develop/update the long term asset health strategy. Ivara's reliability practices like RCM2, Maintenance Task Analysis, Failure Analysis

and PdM Needs Assessments result in ongoing improvements to an asset’s maintenance program, focusing on a proactive, condition-based approach. Ivara EXP supports the automation of this continuous improvement cycle.

PM Implementation

Preventive maintenance as defined by INPO AP-913 related to periodic, predictive and planned maintenance. Preventive maintenance seeks to sustain or extend the useful life of structures, systems and components by detecting, precluding or mitigating degradation. Periodic maintenance refers to PM that is time-based; predictive is condition-based and planned refers to scheduled refurbishment or replacement.

Compiled research over the last 15 years has shown that there are at least 100 likely failure modes for every \$ 1 million dollars in asset value. 70% of failure modes represent defects that can lead to business consequence if unattended. Business consequences are avoided by intervening with recommended corrective action at the appropriate time. When advanced methods are used to determine comprehensive maintenance programs, for 100% of the failure modes of modern industrial systems¹:

- 33 % of failure modes require maintenance to check if the equipment has failed (eg. protective devices)
- 25% of failure modes require maintenance to check if the equipment is failing (deterioration)
- 5% of failure modes require restoration & replacement
- 33% of failure modes can be allowed to run to failure, (either not maintenance preventable or not worth preventing)
- 4% of failure modes require redesign

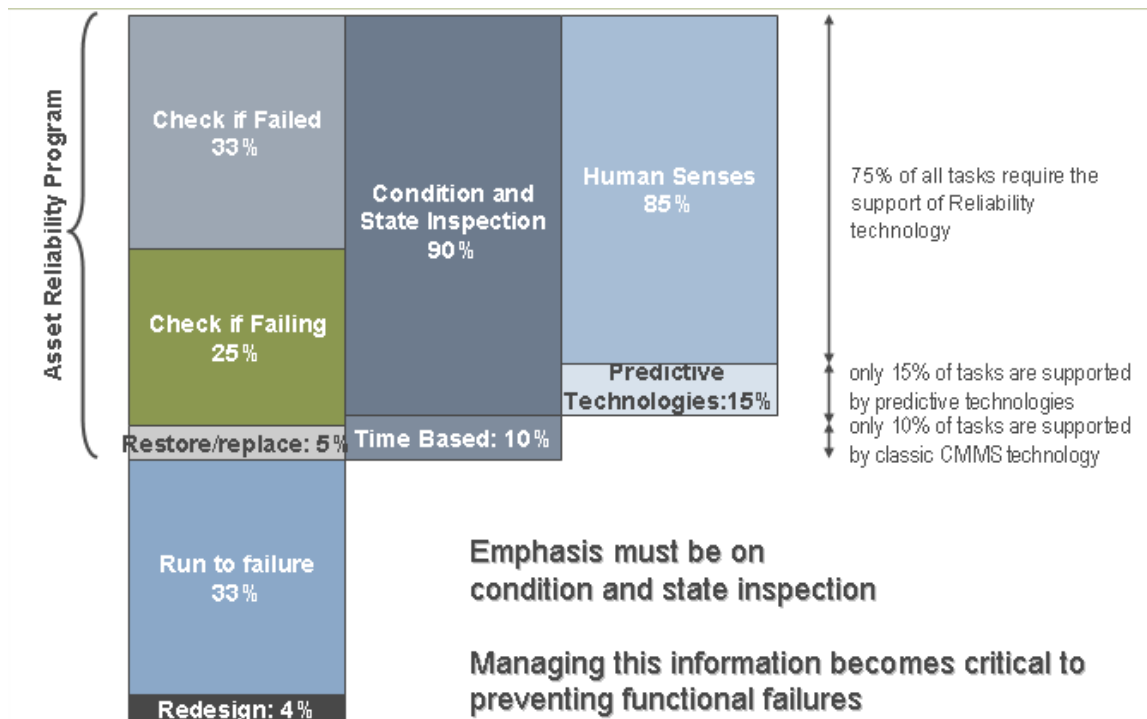


Figure 5: 75% of all asset reliability program tasks require support of asset reliability technology

¹ This information was compiled by Aladon Ltd. Ivara Corporation gratefully acknowledges Aladon Ltd. for the use of these materials.



The asset reliability program therefore addresses 63% of all failure modes. Ivara EXP helps to ensure that the majority of this asset reliability program is acted upon.

Within the asset reliability program, 90% of the tasks require condition & state inspections and only 10% are scheduled restorations & replacements.

Of the tasks that require condition and state inspections, 85% are inspections using the human senses (eg. visually inspecting, listening for abnormal sounds, touching, smelling) and 15% require the use of predictive technology such as vibration analysis, thermography, oil analysis, circuit analysis, NDT, etc.

90% of human senses inspections require the use of descriptive condition indicators and 10% of human senses inspections require the use of numeric condition indicators.

These indicators can be standardized in Ivara EXP to avoid common inconsistencies in data entry. Ivara EXP also contains a library of industry-standard templates, eliminating many hours of data entry.

Proper management of condition and state information ensures timely corrective action is performed to minimize failure consequence. In the nuclear industry in particular, state monitoring can prevent multiple failures and have a significant impact on safety and environmental integrity.

Therefore, reliability software must be employed to ensure the majority of the asset reliability program is acted upon.

For more information on Ivara EXP, visit the Ivara website www.ivara.com.