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Maximize the Value of RBI Program Implementation

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Introduction

What does it mean to “maximize the value of RBI program implementation?” Many owner/users still consider risk-based inspection (RBI) programs a necessary evil or a regulatory mandate that provides little or no return on investment. This article will demonstrate that, if approached logically, a properly implemented RBI program can provide a positive return on investment.

The author has been engaged in managing and auditing RBI assessments for over 25+ years at a wide variety of facilities in North America, the Middle East, and Africa. From lessons learned, it has become clear that if an RBI program is well-thought-out, planned logically, managed properly, and has continuous management support, it can and should provide a positive return on investment.

Lessons Learned

In the process of observing a myriad of RBI implementations, the following issues have routinely been encountered:

- Client management of programs was diffuse (i.e., no one individual had the ultimate responsibility and *authority* to address contractual and technical issues), leading to wasted resources.
- Program technical requirements were not clearly defined or updated over time.
- Required program front-end tasks were not addressed.
- Assessment and implementation of work processes were not executed following logical steps, resulting in re-work.
- Post-implementation, sustainment programs to keep the RBI program evergreened lacked long-term follow-through.

The root causes of many of these issues stem from:

- Owner/user managers responsible for cost and contract performance lacked the means of control over engineering, site decision-making, and resource utilization.
- There was a limited understanding by owner/user team members of the short-term and long-term goals of the RBI program.
- There was an over-reliance on “book smarts” vs. field experience. There was a tendency to define all potential damage mechanisms (DM) rather than the three to six most likely DMs that would determine the inspection program. From an engineering perspective, a lack of field experience to temper academic knowledge, especially on the part of more junior engineers, was observed.
- The value of program implementation was not addressed or was poorly defined.

- There was a tendency to indulge in over-engineering (e.g., the urge to determine the probability of failure or value of a consequence to the second or third decimal point) when the primary goal was to determine the order of magnitude of a probability of failure (POF) or consequence of failure (COF).

RBI Program Implementation

Taking lessons learned into account, a number of steps are recommended to provide owner/users who are implementing RBI with a better chance of realizing a positive return on investment. Many will think the following is a standard operating procedure for setting up any engineering project; however, experience has shown this is not necessarily true when decisions are made to implement RBI programs.

Program Set-Up

The major aspects included in setting up an RBI program include:

- Setting up a unified project organization to manage technical, cost, and schedule aspects. A unified client organization is necessary to ensure the “right hand” knows what the “left hand” is doing.
 - Develop a project team with a single individual tasked with the responsibility of executing the project cost-effectively. Ensure that overall control of cost and technical aspects is invested in a single, qualified individual.
 - Provide the selected individual with the final authority to manage resources.
- Clearly defining project goals.
 - What are the jurisdictional regulatory requirements that must be met?
 - Which corporate standards must be addressed?
 - How can you optimize the site inspection program (i.e., reduce inspection program cost over time without an increase in risk and/or in lost production)?
- Clearly defining work scope.
 - Determine what is to be included and address what is required vs. “nice to have.”
- Determining the desired deliverables:
 - What is to be included in the RBI assessment? Equipment and piping? Equipment only? Piping only?
 - Are inspection plans to be developed? Will isometric drawings (Isos) be included? Will corrosion measurement locations (CML) be defined?
 - Are corrosion control documents (CCD) required?
 - Are integrity operating windows (IOW) to be developed? Will they be implemented as a part of the assessment?
 - Will initial visual and/or NDE inspections be required?

- What RBI software is to be used?
- Ascertaining the quality and accessibility of mechanical, operating, and maintenance data. Data acquisition is extremely important. A significant portion of the resources required for RBI implementation is required for data collection. Considerations include:
 - Is the data in electronic media (PDF format, spreadsheet, etc.) and/or hard copy, and what is the relative amount of each?
 - Where is the data stored (online, library, filing cabinet, desk drawers, single individual, boxes in storeroom)?
 - Can electronic data be shared between geographically separated members of the team (e.g., FTP site, Dropbox, etc.)?
- Determining the scope of systems and equipment to be included in the assessment:
 - Will all units be included, or will only process units be addressed?
 - What is the population of fixed equipment items?
 - If included, what is the approximate number of piping circuits to be addressed? (Note: The number of fixed equipment items can be used to define the approximate number of circuits.)
 - Will pressure relief devices (PRDs) be assessed?
 - Are API-650 storage tanks to be included?
 - Will any rotating equipment (API 691) be addressed?

Document an Optimized Work Process

The ordered set of steps provided below lends itself to controlling implementation resources through the elimination of repeated steps. These steps are applicable to projects implemented by owner/users or others. (**Note:** These steps are equally applicable to a greenfield facility as well as those that may be brownfield.)

The steps are as follows:

1. Define project team interfaces and responsibilities; if to be implemented by a vendor, project and technical interfaces must be defined.
2. Develop and approve a detailed project schedule (a Project Schedule, Level III is recommended).
3. Collect and organize mechanical, process, and maintenance data.
4. Define and document corrosion loops. This will assist in identifying piping circuit limits and must be done if IOWs are included in the work scope.
5. Define and document piping circuits (if in scope).
6. Document design, operating, and maintenance data in appropriate templates for upload into RBI software. If piping circuits are included in the scope, fixed equipment data upload can be done in parallel with the circuitization process, especially if scheduling is an issue.
7. At the completion of step 6, determine item consequence value based on material balance, release type, and inventory. The information gained from this step supports the decisions made

during the next step.

8. Using the information from steps 6 and 7, determine the most likely damage mechanisms and corrosion rates as a basis for determining the probability of failure.
9. Undertake a joint damage mechanism review (DMR) between the corrosion engineers and site operations and inspection personnel. The damage mechanism review ensures that factors not previously documented are considered before calculating failure probability.
10. Calculate item risk. The item risk is typically calculated by the RBI software employed. The risk calculated may be based on rule sets that are a combination of industry standards and owner/user requirements. The item POF and COF values calculated will, in part, determine inspection frequency; the POF will influence the criticality of the corrosion loop or system IOWs.

Note: the next three tasks, inspection program development, CCD development, and IOW preparation, may be done in parallel.

11. Determine inspection program requirements based on item risk. This step results in recommended effective and applicable inspection techniques based on the damage mechanisms identified as part of the RBI assessment. The frequencies of inspection should be driven by consideration of POF value and COF value, not on the calculated risk. The frequencies are often modified by jurisdictional and corporate minimum frequency requirements.

If included in the scope, develop inspection isometric drawings with CML markup. The number and placement of CMLs will be driven by the selected damage mechanisms and recommended inspection techniques.

Additionally, if within scope, perform baseline visual and NDE inspections to confirm assessment recommendations and reassess based on findings.

12. Develop CCDs, which typically document the following:
 - A system flow narrative
 - Corrosion system information – identification of included vessels and circuits with material grade and spec, operating conditions, and damage mechanisms assigned to each
 - System parameters (process chemistry, contaminants, materials of construction, and maximum operating conditions)
 - Listing of primary damage mechanisms
 - Appropriateness of material selections
 - Appropriate inspection techniques for identified damage mechanisms.
13. Develop and document IOWs based on design operating limits and normal process conditions excursions, as well as equipment and piping metallurgy.
14. Ensure that a sustainment program is implemented and is included as a facility management KPI.

As will be seen later, these tasks will need to be undertaken as part of the sustainment process, albeit on a smaller scale.

Option	Description	20-Year Cost Savings: FE	20-Year Cost Savings: w/Piping	20-Year Cost Savings: 200 Circuits	NPV (10%)	IRR
1	Full RBI strategies/5yr average	\$ 35,189,867	\$ 42,503,435	\$ 49,017,004	\$ 11,190,262	54%
2	Restricted RBI, 10yr max/5yr average	\$ 32,798,667	\$ 39,812,235	\$ 32,063,378	\$ 10,455,447	53%
Piping	Average 2k per circuit/5yr historical (2,008)	\$ 7,313,569				
	Average 2k per circuit/5yr historical (200)	\$ 13,827,137				
	Sit Implementation Cost	\$ 435,289				

Figure 1. RBI Implementation Cost Savings.

Vendor Selection Considerations

If a request for quote is established to solicit vendor proposals to perform a facility RBI implementation, the owner/user team should consider the following when reviewing quotes:

- Is the recommended work process optimized?
- Are task labor hours consistent with industry norms?
- Does the vendor team have experienced individuals in critical positions?
- If software is required, determine if the owner/user or vendor will supply it. This should be evaluated against a set of specific criteria.
- After determining program worth, evaluate tender responses to ensure a positive return on investment.

Determine Program Worth

Implementing an RBI program is an investment. Inspection intervals mandated by regulatory authorities can be lengthened with the use of RBI. Once budgeted, the cost of the implementation is known.

The industry is reluctant to discuss RBI program value propositions. This reluctance probably arises from an inference that we are placing monetary value on human life. If implemented and sustained correctly, RBI implementation can result in:

- Increased safety through the application of appropriate inspection techniques at the right locations.
- Reduction in maintenance costs over time through alignment of the inspection program with item risk.
- Improved operator understanding of mechanical integrity requirements through IOWs.

RBI Program Implementation Cost

The total cost of an RBI implementation is dependent on the work scope, equipment count, and data accessibility. Guidelines for determining the validity of an RBI program implementation cost estimate are shared herein.

Some typical resources required for an RBI assessment program are listed below. This list is based on the author's 20 years of

experience and assumes the use of experienced subject-matter experts (SME) in corrosion/metallurgical and process engineering roles. The requirements are as follows:

- Equipment: 2-3 hours per equipment item
- Piping: 3-4 hours per circuit (assumes definition and documentation of circuits)
- Pressure Relief Devices (PRD): 2-3 hours per PRD
- Corrosion Control Documents (CCDs): 40-60 hours per facility/unit
- Integrity Operating Windows (IOWs): 2-6 hours per corrosion loop
- Project Management Allowance: 7.5% to 10% of cost
- Travel Costs
- Software License Cost

When reviewing or negotiating with a vendor, the owner/user team shouldn't particularly focus on rates, especially for lead positions. Use of experienced personnel in senior positions can result in high rates; however, the productivity of experienced, senior engineers can more than make up for the lower productivity of junior engineers lacking relevant experience.

Return on Investment

The potential return on investment for an RBI implementation is illustrated in **Figure 1** by a review of the forecast savings calculated for a North American oil and gas facility. The values provided in **Figure 1** are based on the costs, equipment and circuit counts, the relative risk of each item, and the estimated equipment inspection costs for an actual North American O&G facility. They have likely increased due to inflation.

As can be seen in **Figure 1**, the forecast savings is considerable.

The underlying costs associated with these forecasts were based on the following:

- Assessment scope – Fixed Equipment: 501; Circuits: 2,008
- Equipment counts: Air Cooler - 28; HX - 152; Fired Heater - 19; Pressure Vessel - 234; Tank - 42; Tower - 26

- Average inspection cost: Air Cooler - \$12,000; HX - \$61,000; Fired Heater - \$90,000; Pressure Vessel - \$27,000; Tank - \$125,000; Tower - \$260,000; Circuit - \$2,000

Please note that the circuit reduction was achieved by “grouping” circuits. The premise underlying circuit grouping is to identify groups of circuits of similar risk, metallurgy, and process conditions. Subsequently, one of the circuits in the group is selected for monitoring, thus reducing inspection costs. Should degradation in the selected circuit arise, then the remaining circuits in the group can be inspected as required.

In **Figure 1**, the additional savings achieved from grouping are only double, based on the fact that higher-risk circuits would be in smaller groups and inspected more frequently.

RBI Software Considerations

There are currently many RBI software applications available to owner/users. The author is agnostic on which software application an owner/user should license. However, when selecting an RBI software application, the following should be considered:

- Is the software the integrity management (IM) program or does it support the IM program? It should be the latter. If it is the IM program, it may act as a restraint on inspection optimization.
- What are the owner/user requirements?
 - Will a quantitative, semi-quantitative, or qualitative assessment be followed? In addressing the RBI approach, understand the difference between API 580 and API RP 581. API 580 defines the whys and wherefores for RBI; API RP 581 is a prescriptive, “semi-quantitative” assessment recommended methodology.
 - Is inspection planning and management to be included?
 - Will it be integrated with other tools (e.g., SAP)?
 - Are there corporate information technology requirements that must be met?
 - Is application training desired?
- Will the owner/user obtain a license, or does it desire the service vendor to provide the software? Experience indicates that it is usually more cost-effective for the owner/user to license the software, as costs may be less than those for the vendor, and the software should be used to support program sustainment.
- License Cost – Avoid “bells and whistles.”

Sustainment

Barriers to Sustainment

After initial implementation is complete, day-to-day operations push consideration of “evergreening” or sustaining the program to the background. The reasons for this may be:

- A misplaced assumption that risk remains static or that the process will take care of itself.
- The program is difficult to maintain and manage over a long period:

- There is a lack of a site champion to steward the program over a long time period; program management is often assigned as an “additional duty.”
- There is a lack of budgeted resources.
- The assigned program manager lacks the authority for effective management.
- The RBI program is not part of the management of change (MOC) process.
- There are insufficient site resources to support the program.
- There is a lack of support from upper management.

Requirements for Sustainment

Once a significant investment has been undertaken to implement an RBI program, that investment should be protected. Some means of protecting that investment include:

- Include RBI reassessment as part of the MOC process.
- Continually update the RBI program as a result of:
 - Changes driven by inspection results (e.g., increase or decrease in corrosion rate)
 - Changes in design and/or operations
 - Changes in feedstock and/or product slate
 - Changes in regulatory requirements
- Assign an individual with the authority/responsibility for managing the program.
- Include ongoing sustainment at the facility as an annual management KPI.
- Include sustainment resources in the annual facility budget.

A Final Word

The set-up and execution of an RBI program are equally as important as understanding the technical aspects of undertaking RBI assessments incorporated in API 580 and API RP 581. The undertaking of an RBI implementation has many moving parts, requiring the investment of significant resources. Equal consideration should be given to planning, managing, and executing an RBI implementation to ensure that the assessment is technically sound and adheres to good engineering practices. ■

For more information on this subject or the author, please email us at inquiries@inspectioneering.com.



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Steve has over 40 years of experience in managing and performing risk, reliability, and availability analysis with a background well suited for addressing risk, operating reliability, and life cycle cost issues. In addition to performing risk, reliability, availability, and life cycle cost analyses of refinery, chemical, electric power, and marine systems, he has also managed the development and maintenance of risk and reliability software applications.