The Equity Engineering Group, Inc.

Risk-Based Inspection: The Optimal Management System for Inspection Planning

The API RBI Advantage:

- Designed to integrate into your plant business process
- Quantitative & qualitative risk analysis
- Most extensive materials properties electronic library available
- Full fluid & consequence modeling capabilities
- Numerous technical modules including fixed equipment, HE bundles, ASTs and PRDs
- Developed by ANSI-approved consensus
- Documented in the public domain in API 581

The API RBI Software Difference

Developed by subject matter experts from top refiners and backed by a prestigious industry association, API RBI software technology reflects industry best practices and the expertise of the best minds in the industry. The most comprehensive risk assessment and management tool on the market today, it includes:

- Numerous technical modules to calculate corrosion rates and damage susceptibilities developed by consensus groups' corrosion and materials specialists
- New state-of-the-art fluid property modeler completely rewritten to use improved algorithms that are more robust and accurate to calculate the properties of two-phase fluid mixtures (recipes) over a wider range of operating conditions
- User-defined process streams created from a fluid property database of over 1,800 fluids compiled from such sources as the industry-standard DIPPR® database, which is regularly tested and updated for accuracy
- Outputs that include both the qualitative risk matrix and quantitative data expressed in risk per unit area per year and/or financial risk, in addition to numerous risk, PoF, CoF reports and the inspection plan
- For each component, risk-weighted damage curves for each damage mechanism to show when that mechanism's contribution to end of life shifts - important for developing equipment end of life strategies or assessing operating condition changes
- Ability to provide quantitative output, such as risk in ft^2/yr (or m^2/yr), enabling the user to compare risk reduction for a component, group of components, or unit to the amount of money spent on the fixed equipment reliability program, or the cost of repair or replacement
- Most extensive materials properties electronic library available for associating each component with the appropriate year of the appropriate code for T_{min} calculations

'Best in Class' linking capabilities

API RBI software seamlessly integrates databases and planning practices. The software is built on open architecture, providing the capacity to link to almost any software tool including MySQL, Oracle, and SQL server. This 'Plug & Play' approach allows users to link to existing tools and databases without requiring them to change products or pay additional license fees.

Official API RBI Training

The Equity Engineering Group, Inc (E^2G) is the official API subcontractor for RBI training programs (API 580/581). E^2G's Vice President Lynne Kaley leads the software user group charged with continuing to update API 581. E^2G has also developed courses in Fitness-For-Service (API 579-1 / ASME FFS-1), Pressure Relief System Design (API 520), and offers an API-sponsored course on "Damage Mechanisms Affecting Fixed Equipment in the Refining Industry" (API 571).

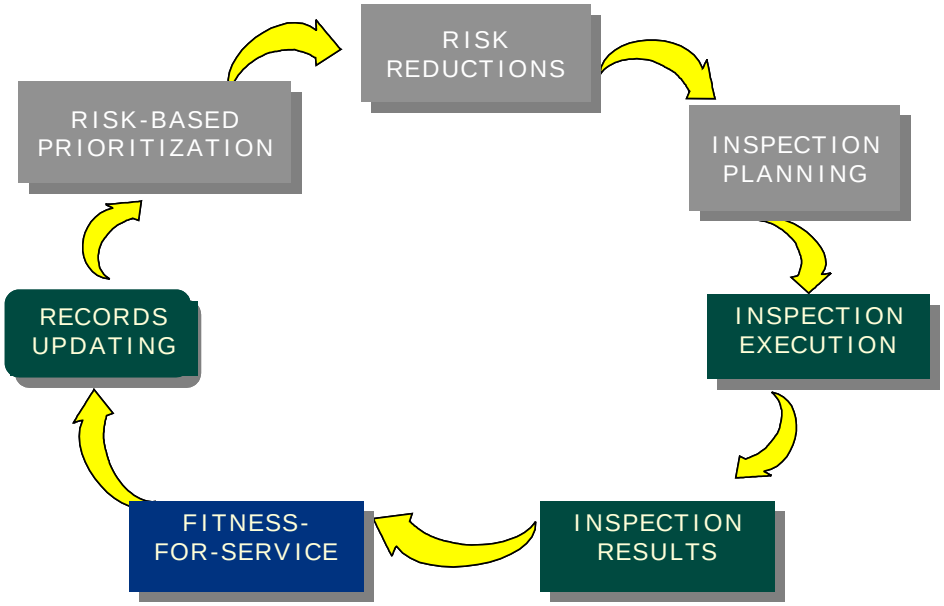
E^2G engineers are uniquely qualified to teach these technologies because we helped create them, and we understand how to apply them though years of hands-on experience at the plants. Hundreds of plant inspectors, engineers and managers have gone through our training programs which are offered in the U.S. and internationally. Courses are available at our Houston Training Center. Check our website at *www.equityeng.com* for a schedule.

An API RBI training session in Houston, TX.

After the RBI Study: E^2G Expertise in Updating and Evergreening

It's important to maintain and update a RBI program to ensure that the most recent inspection, process, operations and maintenance information is included. These follow-up items will help improve the quality and accuracy of an RBI study:

- RBI Re-Evaluation: API 510 and 570 Codes require re-evaluation of a RBI study at a maximum frequency of 10 years. However, for maximum safety and program benefit, E^2G recommends re-evaluation in five years. The results of inspections, changes in process conditions, operational changes and implementation of maintenance practices can all have a significant effect on corrosion/cracking rates and PoF, and can trigger the need for a reassessment.
- Updating files: Conditioning and converting to latest database version includes new data entry, validation and analysis, and developing a new inspection plan.
- Evergreening: Data updating from the current inspection history is performed on an as-needed basis, usually in conjunction with turnaround work, during the Management of Change (MOC) process, to comply with OSHA 1910 HAZOPs, PHAs or audits, or after an unexpected failure.



Integrated Risk Management

To move toward lifecycle management of fixed equipment and realize maximum return on investment from a RBI study, many refiners are using an Integrated Risk Management Program. This type of program, a combination of RBI, FFS and Corrosion/Metallurgical disciplines, enables owner-users to manage equipment integrity through the useful and remaining life of equipment.

- As equipment nears “end of life” for RBI, upgrade to more quantitative FFS or Materials evaluations
- Supplement Probability Analysis with higher level analysis tools, such as FFS
- FFS analysis results can replace the RBI PoF for risk determination and inspection planning
- Replace equipment in-kind or upgrade the original design based on RBI damage drivers
- Initiate new equipment in RBI for management

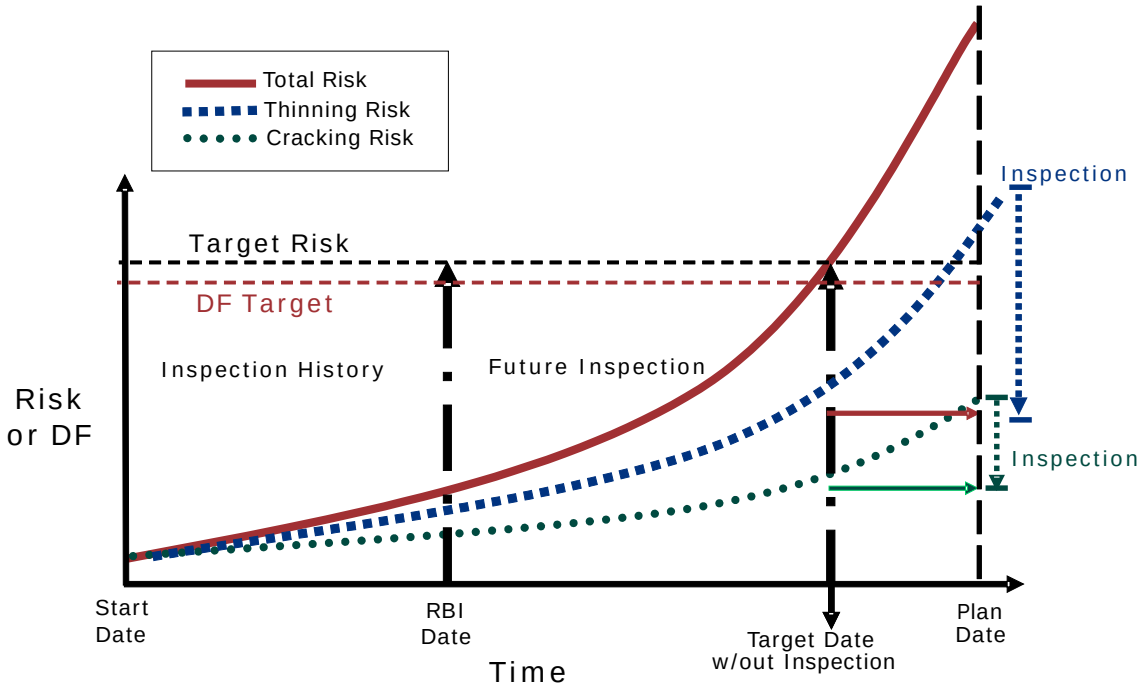
Dynamic links can be developed between RBI and other inspection management tools to streamline inspection planning, reporting and risk management of fixed equipment assets. An integrated approach ensures that analysis is performed at the appropriate level, and that the commitment of resources is balanced with the necessary technology.

Managing Risk through Inspection Planning

Inspection managers can control the probability of a failure in fixed equipment by recognizing the type of damage possible, and by using the correct inspection method at the right location and frequency to find it. API RBI risk assessment technology helps managers make informed decisions about how, when and where to inspect plant assets. The API RBI software Inspection Planning Module helps develop an inspection strategy by:

- Setting priorities
- Identifying 'risk drivers' and inspection opportunities
- Quantifying the current risk, based on inspection results and past effectiveness (frequency, coverage, tools, internal/external inspections)
- Establishing the inspection date (as opposed to fixed interval or condition-based interval setting)
- Providing “what if” capabilities, i.e., future risk based on various options (inspection type, no inspection, repair, replace, etc.)
- Allowing management to compare the payback and risk of operational changes (e.g. crude slate) vis-a-vis impact on safety, environmental risk and equipment reliability
- Providing essential metrics for decision-making

API RBI software includes a comprehensive module for Pressure Relief Devices (PRDs) that provides systematic and in-depth documentation for inspection planning consistent with API 510. The Atmospheric Storage Tank (AST) module is consistent with API 653; and the Heat Exchanger (HE) Bundle module, which serves as a management database, is consistent with and provides vast improvements over existing industry bundle reliability management practices.



The total risk at the plan date exceeds the target risk. Therefore, inspections at the target date are required to subsequently reduce the risk at the plan date.

API RBI technology systematically factors risk into decision-making, helping identify areas of vulnerability and reduce the uncertainties of equipment performance. An effective RBI program confirms equipment condition, identifies damage mechanisms and rates, and predicts Likelihood of Failure, helping inspection managers make informed decisions and target inspection dollars.

API RBI: The *de facto* Standard for Risk-Based Inspection

Equipment availability and the safe, efficient operation of aging infrastructure are key to profitability in the refining industry. So it's not surprising that more and more refiners are making Risk-Based Inspection (RBI) an integral part of their plant work process. Why? Because RBI refocuses inspection dollars and critical related efforts where they're needed most, using risk as a basis for prioritizing and managing an in-service inspection program. This is accomplished by technology that considers the likelihood and probable consequences of an undesirable event.

A relatively large percentage of risk in an operating plant is associated with a small percentage of the equipment items. RBI permits the shift of inspection and maintenance resources to provide a higher level of coverage on the high-risk items and an appropriate effort on lower risk equipment. A potential benefit of a RBI program is to increase operating times and run lengths of process facilities while improving, or at least maintaining, the same level of risk.

The methodology developed by the American Petroleum Institute (API) is the industry standard for implementing Risk-Based-Inspection. Here's why API RBI stands above the competition:

API consensus process for technology

The technology was developed through an ANSI-approved consensus process, and all technology enhancements continue to be reviewed and balloted by owner/user companies through an API-sponsored Joint Industry Project (JIP). Once approved, the technology is programmed into the software and a field test is conducted for validation. Periodically these results are compared to known incidents to check the absolute answer against industry experience.

Technical basis documentation

The technology is thoroughly documented and updated in API 581, available for purchase from API. The software is a validation of solid technology, as its output is tested against this documentation for accuracy.

Quantitative vs. qualitative

A truly quantitative tool calculates risk over time - that is, risk due to failure due to increasing Probability of Failure (PoF) as in-service damage potentially occurs. API RBI is the only RBI tool that provides metrics and calculates PoF due to ongoing damage. This PoF will generate a location in the Risk Matrix that could move (increase) over time, depending on the impact of damage rate on equipment integrity.

Risk-based cost benefit and decision-making

Because a discreet risk is calculated and can change with time, a cost benefit approach can be used to determine the date where inspection is required. The ability to generate cost benefit (in terms of risk reduction/$ spent) leads to more information for risk management and budgeting.

Risk-based to recommend inspection intervals

API RBI technology uses a true risk-based interval. The methodology offers the option to set a maximum interval (in practice 20 to 25 years) and recommends re-evaluation of the RBI study and basis at a minimum of every 10 years (shorter if operating conditions change). That is, the decision logic generating a recommended inspection is not limited by or based on half-life calculations or prescriptive interval approaches. Credit is earned for knowledge and capitalized on in the risk analysis. Half-life calculations or prescriptive interval approaches do not enter into the inspection recommendations - only risk. The impact of this approach is MORE emphasis on high risk equipment (increasing inspection costs) and LESS emphasis on low risk equipment (decreasing inspection costs). The net result is usually a reduction of overall costs, while still reducing risk.

Various companies have developed RBI approaches based on API 580, but most tend to be “black-box” or they are too generic to accurately define an auditable inspection/maintenance plan that provides measures of inspection program improvement. While others may focus on aesthetics, the primary goal of API and Equity Engineering (E^2G) is sound technology, that is, producing PoF, CoF and risk numbers you can trust.

The Equity Engineering Group, Inc. is a recognized leader on aging infrastructure service and support for the oil refining and petrochemical industries. E^2G experts help improve your plant's profitability by supplying state-of-the-art products and services that ensure equipment operational availability, control inspection costs and avoid costly shutdowns.

Interval vs. Risk-Based Inspection Cost-Benefit

Case Study: Inspection Planning for a Light Ends Recovery Unit

Background: The RBI study covered 365 total components (188 PVs & 177 Piping) with production value of $200,000/day. The plant was processing a combination of light ends & high levels of H_2S; risk was driven primarily by susceptibility to Wet H_2S damage and toxic release, plus a prior history of cracking and blistering damage.

Type of Risk	CBI Inspection Plan	RBI Inspection Plan
Future Risk w/out Inspection,	45,743.7	45,743.7
Future Risk w/ Inspection, ft^2/year	38,179.5	6,493.3
Percent Risk Reduction	16.5%	85.8%
Total Inspection Cost ($) within plan	$1,846,220	$1,554,720
Cost Benefit, $	$44,101,153	$156,937,011
Risk Reduction, ft^2/year	7,564.1	39,250.3
Financial Risk w/out Inspection,	$264,381,947	$264,381,947
Financial Risk w/ Inspection,	$218,106,985	$38,571,428
Percent Financial Risk Reduction	17.5%	85.4%

Results: 68% greater risk reduction for Risk-Based versus Interval-Based Inspection; inspection and inspection-related maintenance costs reduced by $291,500 vs. study cost of $22,500. Additionally, the plant avoided unexpected failure costs and damage due to consequence of failure and production losses, and achieved increased safety and improved equipment reliability.

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