An Introduction to Risk Based Inspection for Pressurised Plant Equipment

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INTRODUCTION

Occasional unexpected failures in plants that implement traditional time-based inspection programs, the need to control annual plant operating and maintenance costs, high public expectations in plant safety and equipment reliability have created the need for an optimised plant pressurised equipment inspection methodology. Risk based inspection (RBI) is a methodology that has been developed by the oil and gas, petrochemical and process, and power generation industries for this purpose.

Studies have indicated that in an operating plant, a relatively large percentage of the risk is associated with a small percentage of the equipment items. By combining established principles of risk analysis and industry experience with plant data management, materials science and corrosion prevention, a systematic RBI methodology has been developed which permits the following:

- Production of a risk ranking of plant equipment which allows re-allocation of inspection resources to provide highest focus on the high-risk items and corresponding less effort on lower risk equipment, resulting in improved plant reliability and availability.

- Estimation of change in operating equipment or piping as a result of time dependent deterioration. This in turn allows RBI to be a tool that allows plant operators to vary shutdown intervals for equipment inspection, thus offering operational flexibility and minimum shutdowns.

- Management of risks associated with operating equipment, thus assuring enhanced health-safety-environment protection, appropriate return on investment and optimum utilisation of inspection personnel and resources.

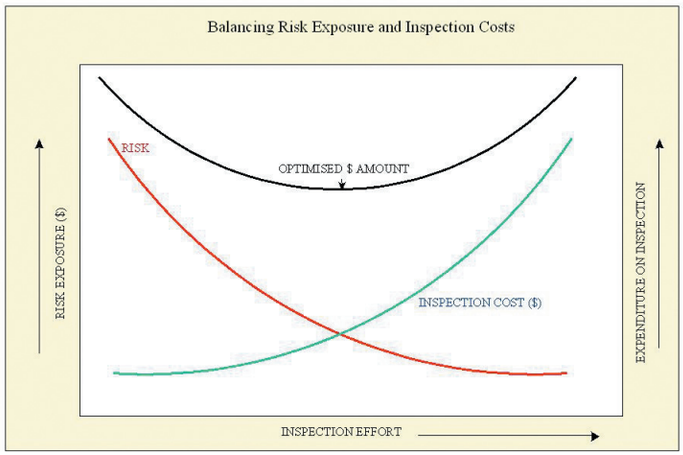

Figure 1: One of the main driver for RBI: Cost benefit optimisation of inspection strategy

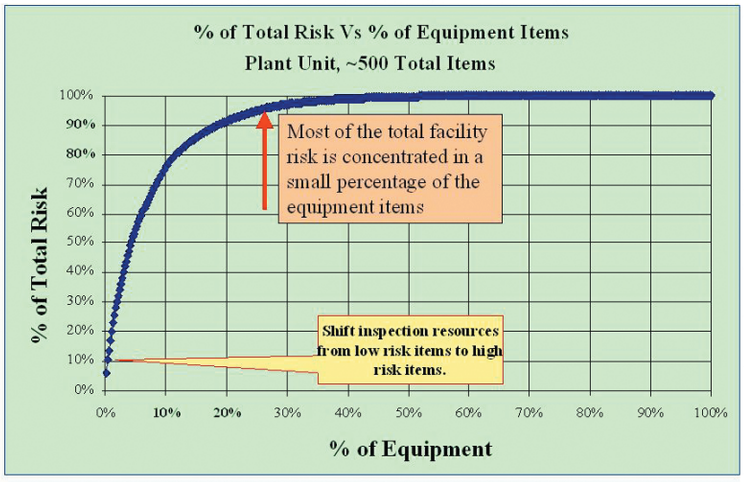

Figure 2: Typical risk distribution in plant equipment

BENEFITS

RBI has the potential to reduce overall inspection costs by providing a system of prioritising inspections so they will fully address all safety, health and environmental concerns. A risk based ranking of all equipment items provides the basis for allocating inspection resources so that potentially high risk areas can be subjected to more effective and more comprehensive inspection or monitoring, while low risk areas are inspected in a manner that commensurate with the lower risk. RBI programs are totally dynamic. Perceived

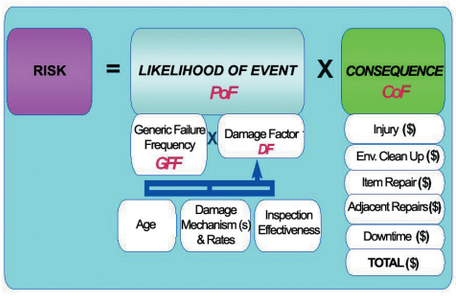

Figure 3: The RBI risk calculation

risks are updated at the completion of any inspection or even the inspection of similar equipment, changes to process conditions, process upsets or deviations, etc. Any of these may cause a change in inspection frequencies or changes to the inspection scopes to detect new degradation methods.

The outcome of an RBI program is the same as the traditional time-based inspection program, i.e. ensuring equipment is safe to operate and the equipment complies with applicable Codes, Standards and Regulations. The main difference is the RBI methodology provides a systematic, logical, repeatable method of determining the inspection scope and the most appropriate time to carry out inspection. The RBI methodology helps allocate inspection resources more efficiently and promotes better quality inspections without compromising safety, reliability and compliance.

GENERAL PRINCIPLES

The RBI method defines the risk of pressure-containing equipment as the combination of the likelihood of failure and the consequences of that failure. This combination produces an estimated risk for each equipment item. Risk can be expressed in terms of personal safety, damage to equipment, environmental impact and business interruptions. The influence of inspection on risk is thus quantified and risk reduction can be evaluated.

The RBI method defines the risk of operating equipment as the combination of two separate terms: the likelihood of failure and the consequence of failure.

The likelihood analysis assesses the probability and effects of specific failure mechanisms based on:

- The history of the equipment;
- The history of similar or identical equipment in identical service conditions;
- The experienced and anticipated degradation methods based on the current and predicted service conditions.

The consequence analysis of a release (instantaneous or continuous) is calculated by:

a. Estimating the release rate and release amount based on:

- Pressure differentials;
- Size of opening;
- Leak detection methods;
- Isolation capabilities.

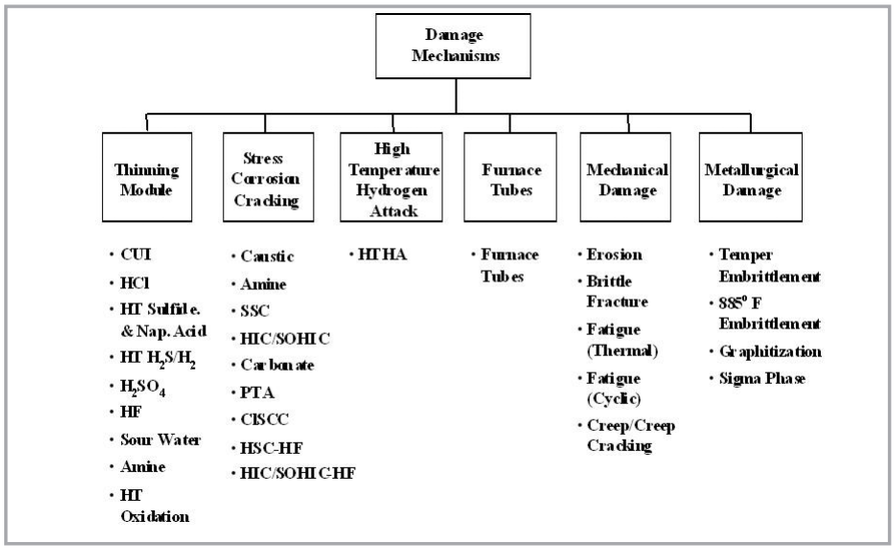

Figure 4: API typical likelihood mechanisms

b. Predict the outcome of the release based on:

- Amount and rate of release;
- Composition of released material;
- State of released material;
- Area affected by release;
- Safety, environmental and business interruption effects.

The likelihood and consequences are combined to produce an estimate of risk for each equipment item and piping system. The items can then be prioritised based on the risk calculations.

METHODOLOGY

The methodology for applying RBI to the oil and gas, petrochemical and process industries was developed with the participation of Det Norske Veritas for a sponsor group under the American Petroleum Institute Committee on Refinery Equipment, and is laid down in the Base Resource Document API 580. Since then, numerous standards and guidelines have been published and are available to assist plant operators in the application of RBI to pressurised plant equipment. Standards such as the American Petroleum Institute Base Resource Document on Risk Based Inspection (API RP 581) for example, provide guidelines that can be used to assist in the development of a comprehensive RBI for oil refineries.

A three level methodology for risk-based inspection planning have been developed to suit a range of users. The choice of method is generally guided by the following considerations:

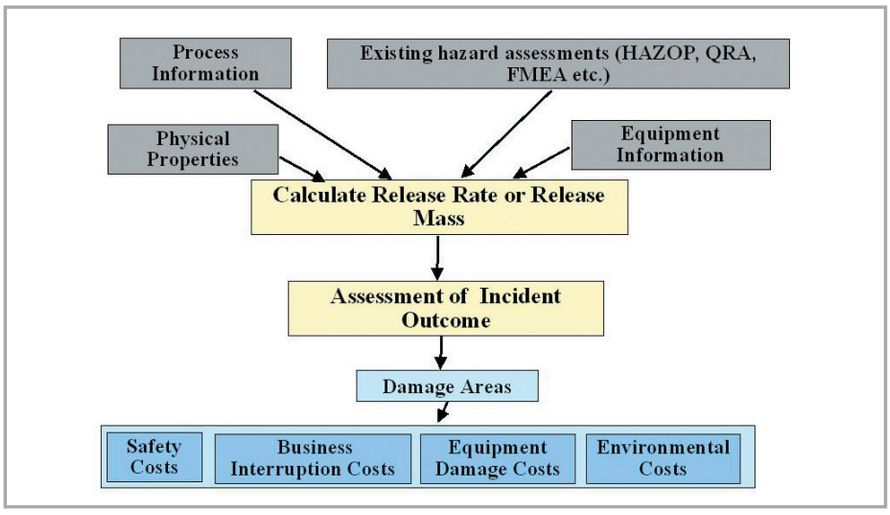

Figure 5: Consequence considerations

- The Level I method is a qualitative method that can be used as a course screening of equipment. It is used when equipment replacement cost is low.
- The Level II method is based on simplified calculations. It is used when replacement cost is high.
- The Level III method is a fully quantitative method using thorough calculations. It is used when the consequence of equipment failure is of high safety concern and when replacement cost is high.

The development of RBI has reached the point where specialist software prioritisation programs are available as a tool that manages equipment data and analyses the position of the plant equipment and piping within a risk matrix. A report is then issued as a basis of an inspection plan for a given plant.

Software-based decision logic leads to calculation of the extent of damage with time. Together with safety and economic-impact models, the software allows the change in risk with time to be used to select when inspections should take place. In addition, the software will allow data transfer from existing inspection-management databases and calculate quantitative risk levels for safety and economic risks.

Together with a cost-optimising inspection-planning module, where the plant operator's inspection procedures can be used to select which procedure is most cost-effective in reducing risk levels, the result is an inspection plan stating:

- Which item to inspect, when, and how
- The expected changes in risk as a result of that inspection

This can be exported back to the inspection-management database, or used to drive inspection directly. Results of inspections are used to update the extent of damage and derive revised inspection plans based on the new risk picture.

STATUS OF DEVELOPMENTS RELATING TO RBI

The Department of Occupational Safety and Health, Malaysia plans to amend the Factories and Machinery Act to incorporate the internationally recognised RBI principles. The amendment will be defined as the Special Scheme of Inspection (SSI) with provisions for inspection scope, application, methodology, competent personnel and performance measurement standards. A draft guideline for implementation of the SSI has been issued for industry review. This document will be formally issued for industry use after the necessary government approvals are obtained.

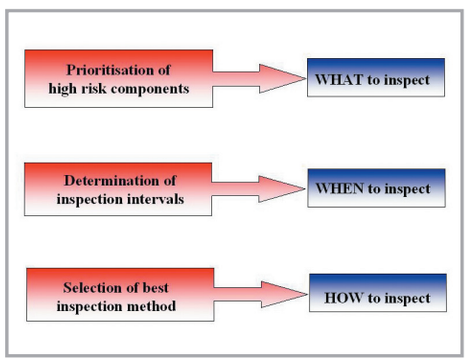

Figure 6: RBI deliverable and inspection guideline

The European Union Commission and major plant operators in Europe commissioned the Risk Based Inspection and Maintenance Procedures for European Industry (RIMAP) Project in 2001. The objective of the RIMAP Project was the development of a unified approach to making risk based decisions within inspection and maintenance for a wide range of industries. The RIMAP Project was completed in 2005 and a proposed European Standard on RBI is one of the main deliverables of the RIMAP Project.

Many countries and multinational companies have endorsed RBI as an approach to manage their inspection programs. For example, the Health and Safety Executive being the body that enforces safety and health regulations in the United Kingdom accepts RBI as the basis for inspection and maintenance planning for some time now. In addition, many companies such as BP, Norske Hydro, Petronas Carigali, Phillips Petroleum, Saga Petroleum and Statoil have implemented RBI for their offshore platforms for some time now. ■

REFERENCES

[1] API RP 580 (May 2002) – Risk Based Inspection, American Petroleum Institute.

[2] API RP 581 (May 2000) – Risk Based Inspection Base Resource Document, American Petroleum Institute.

[3] DNV-RP-G101 (January 2002) - Risk Based Inspection for Offshore Topsides Static Mechanical Equipment, Det Norske Veritas, Norway.

[4] Contract Research Report No. 363/2001 - Best Practice for RBI as a Part of Plant Integrity Management, Health & Safety Executive United Kingdom.