Is Risk Based Inspection the Right Approach for You?

F. J. Vacha
Applied Integrity and Reliability Consulting

Summary
Over the last several years, risk based inspection (RBI) has been the subject of numerous discussions in the maintenance and inspection communities of the process industry. RBI is a subset of more general risk based decisional (RBD) processes. Increased use of risk based decisions stems from a continuous need to improve on prioritization of resource allocations. It is probably the best method to achieve lower maintenance costs while improving equipment reliability. To achieve these results, initial development of RBI often requires the formation of a temporary, but dedicated, group to implement the system. This paper attempts to sketch an outline of the RBD and RBI processes.

Risk Based Decision Making (RBD)

The main question concerning RBD or RBI is whether or not business decisions should be based on risk evaluations. In actuality, all important business decisions have almost always been supported by either explicit or implicit risk benefit considerations. The challenge is to make existing processes more effective and results comparable across the corporation.

Risk based decisions are not "risky decisions." The objective of RBD is to reduce the risk to a minimally economically justifiable level. In the hands of a skilled user, it is a very effective tool. Due to a lack of experienced assistance, little availability of standardized processes, the perceived need to develop individually tailored approaches for specific business processes, and the amount of effort required to do so, the adoption of RBD processes remained underutilized until recently.

These concepts were being used more occasionally, particularly by larger corporations, and then only when the stakes were high. That situation is now rapidly changing. Risk assessment can be applied cost effectively even to smaller business decisions. This is not difficult for a dedicated team with experience in such process overhauls.

Experience shows that when considering more complex business cases, the explicit or structured approach frequently brings about significantly different results compared to those developed during the implicit, "experience" or "instinct" based, assessment. In inspection applications in one refinery, assessment of risks were reduced in 60% of cases, increased in 10 -15% and remained unchanged in 30%. There are savings through reduced inspection and maintenance programs and, more importantly, savings were realized through the prevention of unplanned incidents.

To achieve a maximum benefit from RBD, standard procedures should be applied to all important decision processes in a corporation. For example, when risk based decisions are developed and used in one department, it is relevant for the CEO to objectively compare the risk of individual options across departmental boundaries during budget fund allocations. To achieve comparability, it is important to implement a meaningful measurement of standard business risk, expressed in costs in most cases.

While the concepts of RBD are similar in most cases, practical methodology will vary for individual industries or business processes. For example, assessment of critical strength loss risk required to win a battle will differ significantly from the methodology used to decide to shut down a process unit for repairs. In addition, techniques used for industries where large number statistics can be successfully applied, will be quite different from situations where there is little or no reliable data. If standard methodology is not set, the process can become complex, economically unattractive or unusable by others. It is possible, at least within the confines of a single corporation, if not a single industry, to develop a set of standards and adjust methodologies that will allow a reasonably good comparison of individual cases. Once these are computerized and institutionalized, their use becomes routine.

Concepts of Risk and Criticality

In its simplest form, Risk is often defined as:

$$R = p \times c \ (\times e)$$

R= the risk value of the investigated event, expressed in arbitrary units;
p = the probability of the investigated event to occur;
c = the consequence of the event when occurred;
e = is the exposure factor. This can be added to the equation to represent the fraction of time the considered items are actually exposed to the risk situation. (In process industries, the "e" value is often close to 1.0 and is neglected.)

A similar concept to risk, also occasionally used, is Criticality. This can be defined as:

$$C = p' \times c \ (\times e)$$

C = defined as the criticality of the investigated item expressed in arbitrary units;
p' = defined as the predictability of an event;
c = the consequence of the event, same as above.

Other significantly more complex relationships can be found in related literature. While it is very similar, the concept of predictability is sometimes easier to define and understand. In situations where expert judgment is used, it may offer an advantage especially in early stages of criticality assessment processes. However, both approaches are conceptually identical and can use similar standards.

The above concepts are often expressed in the form of a "risk matrix." Numerous risk matrixes have been proposed for the RBI process, ranging from a simple 3 x 3 matrix to a sophisticated 5 x 5 form with customized risk patterns and multifunctional parameters allowing cross comparisons. An example of a simple 3 x 3 matrix is shown below:

M 50-250	H 250- 750	VH >750
L 10-50	M 50-250	H 250- 750
VL 5-10	L 10-50	M 50-250

Consequence

Legend

- VL = Very Low, L = Low, M = Medium, H = High, VH = very high: ratings applicable to Risk, Probability and Consequence;
- VG = Very good, G = Good, P = poor: ranking applicable to Predictability;
- Numbers represent an example of possible corporate convention if risk is to be expressed as numerical value. This is suitable for finer distinction among options or for further computations.

The above matrix shows how combinations of different probabilities (predictability) and consequences result in various levels of risk (criticality). From the above, it is also clear that both components must be first considered separately, and only after their valuation, can they be plotted on a matrix for the risk calculation made. Absolute values assigned to probability/predictability and consequences are user-defined as they are specific to particular business processes. For example, a financial loss of $1M would have disastrous consequences and be rated as High in one company, while it would be considered a minor event and be rated as Low in another company. The quality of the rating may be approximate or quite accurate based on the quality of the available database(s) and importance of the evaluated event.

The argument is often made that the ratings are “subjective” and do not represent absolute values. In initial stages of RBI implementation, determination of “absolute” values of risk is not necessary for it to be effective. However, proper and expert evaluations of individual pivotal system components are critical, especially in the early stages. This requires an initial assessment, survey or audit. The relative value of risk is more important since the RBI process is used mainly for work prioritization of limited resources and serves to ensure that resources are applied in areas where they will have maximum effect. Later, with additional process refinement, more absolute, “harder” values can be arrived at and used.

The second part of a risk evaluation exercise is an assessment of options proposed for the risk reduction. It is also essential to understand this methodology. Different risk mitigating options may have vastly different payouts per unit of reduced risk. Such methods should also be included in a good RBI program.

What is Inspection?
Inspection is an activity aimed at evaluating the condition of equipment, based on its useful and reliable life. Inspection is based on the knowledge of equipment's degradation mechanisms, which affect equipment integrity. Then, using the best fit for purpose techniques, you can determine a reliable and economically justified maintenance plan for its lifespan. This approach contrasts with the method of time-based inspection, which is usually prescribed by regulatory agencies or internal directives.

In most Western European and North American process industries, inspection activities are separated and distinct from those of daily maintenance. However, not all maintenance departments are organized with separate inspection activities. Separate inspection activities are common only for stationary pressure equipment. For most other types of equipment, such as rotating or electrical equipment, maintenance and inspection functions are often combined. The main reasons for a functional split in the case of stationary equipment are the complexity of degradation mechanisms, the skills required for its detection, and evaluation can differ quite distinctly from skills required for repair.

Also, contemporary trends and high utilization factors move us away from time based inspection and towards condition/risk based inspection for stationary equipment by putting additional emphasis on accurate condition forecasting and the requirement for highly skilled specialists.

Risk Based Inspection
The early concepts of RBI applicable to the petrochemical and refining industry were established in Canada in 1983 when the first computerized inspection model, based on criticality, was implemented by Shell Canada. Since then, several more sophisticated proprietary and commercially available systems have been developed.

As indicated earlier, the reasons for implementing RBI methodology are largely based on long-term economics. It allows the user to sustain long term **reduction of maintenance costs while improving reliability**. Savings of 15% after the first year of implementation are common. In less efficient maintenance organizations, up to 70% of costs are not used to perform maintenance (which would be necessary from the defined equipment reliability point of view) at the time when it is carried out. This represents a monetary reserve from which up to 50% cost reductions could be realized. This is actually happening in some corporations, as a more selective approach to inspections and repairs takes hold.

Some specifics of RBI application in process industries
The petrochemical and refining industries place emphasis on stationary equipment inspection. This represents a greater portion of the maintenance budget and is often found on critical path during repairs. Its failures also have the greatest potential for the largest business impacts. Implementation of RBI in most companies is usually started on stationary equipment. Efficient implementation usually requires formation of a dedicated team that has a clear mandate and is charged with the development and integration of RBI into the company's normal business processes. Without such commitment and guidance on the front-end effort, RBI implementation can become mired in details by less experienced users and result in failure. As a result, RBI is applied

in several stages as some activities can be paralleled if sufficient resources are available.

Principal steps

- During the preparatory work, the criticality or risk assessment methodology is selected, proposed and agreed on. Often external expertise is utilized to complement in-house experience. The objective is to reduce risks until they reach a level below which further reduction is not economically justifiable. Individual measuring standards and acceptable levels of residual risk for all stages of the program are defined and agreed on.

- The next step evaluates and ranks several known risky situations based on current records and the employees' knowledge. This is used as a test of the methodology in order to rank known risks, to focus attention on their resolution and to show early results.

- During the third stage, structured approaches to identify degradation mechanisms and conditions leading to failure are initiated. This is the most technical and expertise demanding stage. Structured expert judgment is often the preferred technique in the early stages of RBI, before a reliable database suitable for mechanized analysis is developed. Primary risk ranking for critical equipment and the whole process units are developed at this time.

- In the fourth stage, analysis of integrated records is carried out and the completion of additional inspections is scheduled to allow a complete risk assessment for all critical equipment. Detailed long-term inspection and repair programs are defined at this stage. This is also when the most intensive staff training takes place, preparing them to efficiently takeover administration and continuous improvement of the RBI program.

Several techniques and standards are in use, mostly developed as proprietary techniques by large corporations. RBI techniques are now being developed on the open market and have become available to smaller corporations, enabling them to improve their equipment reliability while reducing costs.