



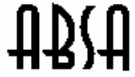
the pressure equipment safety authority

# **Risk-Based Inspection Requirements for Pressure Equipment**

**(AB-505)**

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**Revision 1**



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## FOREWORD

This document defines requirements for the development and use of risk-based inspection (RBI) to manage the integrity of the pressure equipment operating in Alberta. While a RBI program is not mandatory in Alberta, a company who chooses to apply RBI per ABSA Inspection and Servicing Requirements Document (ISRD) for pressure equipment must meet the requirements specified herein.

The current version of this risk-based inspection document and the ISRD are posted on the ABSA website [www.absa.ca](http://www.absa.ca). These documents were developed and are updated periodically by a committee comprising representatives from owner-users and ABSA. This process is designed to ensure that these documents reflect current industry practices and safety legislation.

If you have any suggestions on how to improve this document, please send them to ABSA at 9410 – 20<sup>th</sup> Avenue, Edmonton, AB, T6N 0A9, Attention: Satwant Rakhra, [rakhra@absa.ca](mailto:rakhra@absa.ca).

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**This document defines the requirements that must be met when an owner incorporates formal risk based inspection processes into their Owner-User Integrity Management System registered with ABSA.**

**Dr K T Lau, PhD., P. Eng.  
Chief Inspector and Administrator**

## 1.0 PURPOSE

The purpose of this document is to promote and maintain pressure equipment safety in Alberta by defining the essential elements to be addressed in a RBI program. Through the use of these guidelines, it is intended that RBI programs will be applied correctly based on sound judgement and principles, such that the inherent fiscal and operational benefits of RBI can be realized and pressure equipment safety enhanced.

RBI is a complex process that requires careful and detailed development and planning. It is not the intent of this document to provide comprehensive information regarding RBI program development. That information is provided in the referenced documents which are listed in Section 8.0 - Referenced Publications.

A comprehensive risk-based program will typically consider environmental, economic, and other factors in addition to safety. Since ABSA is concerned with the safety and integrity of pressure equipment, this document primarily addresses safety and environmental considerations only.

## 2.0 INTRODUCTION

RBI is a management process by which inspection and other mitigation requirements are determined based on the inherent risk of a pressure equipment item. The inherent risk of an item is considered to be the product of the likelihood of the failure of the item, and of the expected consequences should that failure occur.

In general, the risk is determined in accordance with a defined, logical and consistent method. The likelihood and consequences of failure are determined for each item through a qualitative assessment (or in some cases more rigorously through a quantitative assessment). The assessment should be based on identified degradation mechanisms, defined failure modes, design data, process data, inspection and operating history, and equipment location relative to human and environmental influences. Based on this assessment the relative likelihood and severity of a failure is determined. These values are typically plotted on a matrix with the location of the point in the matrix indicating the risk hazard associated with the item. Items which exhibit both a high likelihood and high consequence of failure will be identified as requiring the most attention from inspection and other mitigation techniques. Similarly, items with a low likelihood and low consequence of failure would receive a relatively lower degree of attention.

The use of a RBI approach to manage pressure equipment safety offers many benefits. Primarily, it allows inspection resources to be allocated in the most efficient manner to minimize risk. A proper RBI assessment may show that a reduced frequency or scope of inspection for lower risk items is justified. It allows a benefit analysis to be performed whereby the owner can ensure that inspection resources are being allocated properly. Traditionally, mitigation (such as inspection) is focused on reducing the likelihood of failure. Since a RBI program causes the owner to

consider consequences, other mitigation methods designed to reduce the consequences of failure may identify alternate techniques that should be applied to a particular vessel or system.

A RBI program can be very beneficial. However, it cannot be over-emphasized that such a program must be carefully planned and controlled, and requires skilled, knowledgeable personnel to operate effectively. If not properly applied, the process can focus attention away from items that are incorrectly assessed as having a low risk. This can result in hazardous situations.

### **3.0 DEFINITIONS**

- 3.1 Public Occupancy means any facility where members of the general public are likely to be present. This includes educational facilities, hospitals, office buildings, apartment buildings, and plant control rooms.
- 3.2 Owner-User means an organization that has provided a satisfactory program for managing the integrity of their pressure equipment and has been issued an ABSA Certificate of Authorization to perform the activities defined in their accepted Owner-User Quality Manual on file with ABSA.
- 3.3 Pressure Equipment means a thermal liquid heating system or any containment for an expansible fluid under pressure, including, but not limited to, fittings, boilers, fired heaters, pressure vessels and pressure piping systems as defined in the Regulations.

### **4.0 APPLICATION AND LIMITATIONS**

RBI may be applied in any industry in Alberta, provided that the requirements of this document are satisfied. In addition, all RBI programs must meet the intent of API RP 580 Risk-Based Inspection downstream segment (qualitative assessments at minimum). The pressure equipment in a facility to be managed under a RBI program needs to be clearly identified. Consideration should be given to the impact on the auxiliary equipment not included in the RBI scope. RBI is not to be applied to public occupancy equipment.

RBI is a complex process that requires a thorough understanding of processes, material degradation and failure mechanisms, mitigation strategies and techniques, inspection techniques and their reliabilities. Companies must therefore meet and demonstrate certain basic prerequisites before embarking on a RBI program in Alberta.

For a RBI program to be accepted in Alberta, the company must be an Owner-User with a valid Certificate of Authorization from ABSA. The company must maintain an accurate inventory of all pressure equipment along with relevant design details. The scope of the Owner-User Program must include pre-commissioning inspections

(inspection of new installations) since this is the time when the initial risk assessment of new installations should be made. The Owner-User audit performed by ABSA must include an assessment of the RBI program to demonstrate compliance with this document.

A company wanting to implement a RBI program must have the resources and structure to make such a program work. RBI and inspection planning require a range of technical input and perspectives from different disciplines and therefore is best undertaken by a team. The number in the team and its composition will vary depending on the complexity of the installation. Typically, the involvement of experienced corrosion, materials, maintenance, process engineers/technologists and operating personnel is necessary.

The team should have a team leader with the authority to manage the team and the responsibility of ensuring that an appropriate RBI plan is developed. If a company proposes to contract some or all of this work to an outside vendor, then the process for controlling outside consultants must be defined. External experts and consultants can contribute valuable technical knowledge and experience, and also provide a useful degree of independence and objectivity in assessing the risks and the adequacy of the proposed system.

The owner shall have a documented assessment process in place, and shall be responsible for assuring that the consultant is capable of providing integrated services and assist in the development of the RBI program. It is essential that the personnel involved in the operation of the RBI program are intimately familiar with the processes, operating parameters, procedures, history and other factors to make thorough risk assessments. Furthermore, since risk tolerance is highly subjective, it is mandatory that senior management has documented and approved policies and procedures governing RBI and has defined acceptable risk tolerance.

## 5.0 INSPECTION INTERVALS

The ABSA document *“Inspection and Servicing Requirements for Pressure Equipment”*, establishes requirements for assigning inspection intervals for pressure equipment and servicing intervals for pressure relief devices. It covers inspection practices and how inspection and other information is to be used to establish maximum inspection intervals through a progressive time based grading system. Tables in the ISRD list the maximum intervals that can be assigned for specific types of equipment.

There is provision in this document to allow owners who have established a formal RBI program in accordance with this RBIP document to use their RBI program to establish inspection requirements and the listed maximum inspection intervals, without applying the progressive time based grading system defined in the ISRD document.

## 6.0 BASIC REQUIREMENTS OF A RISK BASED INSPECTION PROGRAM

For a RBI program to be successful in assessing risk and assigning appropriate inspection intervals and mitigation techniques, the program must meet some basic requirements. The following sections address the minimum requirements that must be met for a RBI program to be acceptable for pressure equipment in Alberta.

### 6.1 Logical and Fully Documented Process

The assignment of a risk-based inspection interval for a pressure equipment item must follow a well defined, rigorous, and logical process to ensure that all pertinent information has been considered. Otherwise, critical factors may be overlooked.

The RBI process must be clearly documented in a written procedure. This procedure must be a referenced and controlled document under the Owner-User Quality Manual. The procedure must define, in detail, each step to be taken during the risk assessment process. The procedure must detail how hazards are defined for each pressure item, how the likelihood and consequences of failure are established, and how this is used to determine risk level and inspection intervals. The Owner-Users RBI program must be assessed and accepted by ABSA for compliance with this RBIP, prior to using RBI processes to determine appropriate inspection and servicing intervals for pressure equipment items.

### 6.2 Personnel

The RBI program must define the personnel who will participate during each stage of the risk assessment, including their required qualifications, training, plant specific knowledge and experience. Key RBI team members may include: a team leader, equipment inspectors; a corrosion specialist with sufficient qualifications and experience to understand the process, predict failure mechanisms and identify limitations in inspection techniques; process specialist; operations and maintenance specialist; management; risk assessment personnel, environment and safety personnel and financial and business personnel. The role of the company chief inspector in the RBI process must be clearly defined.

Part of the RBI process must include a documented process for assessing the competency level of the personnel involved in the risk assessment to ensure that the team has the required knowledge and experience to make sound judgments. The RBI team members shall have appropriate knowledge of the company's RBI and pressure equipment integrity management program, and of risk analysis. The team leader must have sufficient all round technical knowledge and experience of the plant to know what information is required and where to find it.

All personnel participating in the RBI program must be fully trained in the program and understand the implications of the decisions made. Their training must be documented.

The impact of personnel changes on the RBI program must be managed and controlled to ensure the continued competency of persons involved in the RBI process.

### 6.3 Documentation

It is essential that all RBI assessments be clearly documented with all factors contributing to the final risk assessment defined. At minimum the documentation must include:

- team members performing the assessment and their qualifications,
- re-assessment interval,
- factors used to determine risk,
- assumptions made during the assessment,
- risk assessment results (unmitigated risk levels),
- actions required to move to new mitigation risk levels, and
- mitigated risk levels.

This documentation will allow risk assessments to be reviewed on a regular basis and to be revised based on changes to process, updated inspection information, and other new information. This documentation will be required during internal and ABSA audits of the RBI program.

### 6.4 Pre-commissioning Inspections

A pre-commissioning inspection must be completed on each pressure equipment item. This is an integral part of an owner's integrity management system. The pre-commissioning inspection shall include verifying that the equipment and its installation complies with the Safety Codes Act and Regulations and any specific owners design requirements prior to being placed in operation. The RBI analysis must be revalidated, if equipment is relocated and when the service or ownership changes.

When used equipment is purchased, equipment has been repaired, the location or service has been changed or when the inspection, service, maintenance and records cannot be fully validated, the risk is increased accordingly. The RBI program shall include a re-assessment process to address such situations per Section 7.7.

### 6.5 Management of Change

A critical factor in the success of a RBI program is the ability of the company to manage change. Even seemingly minor and insignificant changes can have a tremendous impact on the likelihood or consequences of pressure equipment failure.

Management of change must be controlled by a written procedure that is referenced in the Owner-User's Quality Manual. The process for evaluating the impact of changes must be addressed in the RBI program and the documentation must be in sufficient detail to enable the impact of a change to be fully understood.

The Piping Inspection Code (API –750) and OSHA 29CFR part 1910 provide guidance on the development of an effective management of change program.

## 6.6 Computer Models

Computer models developed to assist in the determination of risk must be used with great care. It is important that the persons using the model have had the required documented training, are competent and understand how the computer determines risk, based on the data that it receives.

The system must ensure the integrity of computer records. All computer generated risk levels must be reviewed and verified by the owner to be consistent with the principles used to develop the RBI program.

## 7.0 **DETERMINATION OF RISK**

The following discusses the typical stages of a RBI assessment and defines the minimum elements that must be addressed during each stage. The stages are as follows:

- System Definition which identifies what has been and what will be assessed,
- Hazard Identification,
- Consequence Assessment,
- Likelihood Assessment,
- Risk Determination,
- Mitigation/Inspection Plan and
- Reassessment.

As the exact process for assigning risk to pressure equipment will vary from company to company, it is not necessary that the system outlined in this document be followed, provided that all essential elements are addressed. Much more detail regarding risk assessment is available in some of the referenced documents, particularly API 580.

### 7.1 System Definition

This stage involves the collection of pertinent data to be used in assessing the likelihood and consequence of failure for each pressure item.

As a minimum, the following data must be considered and collected if appropriate:

- operating pressure and temperature (including transient and upset conditions),

- process fluid description (including flammability, toxicity, and reactivity),
- process stability,
- process impurities,
- equipment design data (including materials, temperature, and pressure),
- inspection and repair history,
- operating history,
- current mitigation strategy,
- personnel exposure,
- proximity to the public,
- environmental consequences, and
- integrity operating windows.

The RBI program must define the required information to be collected.

## 7.2 Hazard Identification

Once the background information is in place, the hazards must be identified. This involves identifying potential and credible degradation modes and damage mechanisms expected based on the equipment being studied, using the inspection and process data and industry experience. OSHA 29CFR part 1910 can be referenced. This stage is critical and requires careful analysis by a corrosion specialist having sufficient detailed knowledge of the equipment, process, and failure mechanisms to make accurate evaluations (see Personnel above).

All basic modes of degradation must be considered when identifying damage mechanisms for equipment. Modes of degradation include: thinning due to corrosion or erosion, cracking, metallurgical changes, mechanical forces, etc. Damage Mechanisms Affecting Fixed Equipment in the Refining Industry (API 571), Inspection of Pressure Vessels (API 572), and Recommended Practice - Risk-Based Inspection (API 580), provide information regarding modes of deterioration.

At this stage, potential failure scenarios (for example, pit to leak to ignition, or crack to rupture) are to be identified based on the damage mechanisms expected. This will assist in evaluating consequences and mitigation methods in later stages.

## 7.3 Consequence Assessment

As previously discussed, the consequences of a failure of pressure equipment can include impact on public safety, employee safety, the environment, and the direct and indirect financial costs. The focus of this guideline and any RBI program applied to pressure equipment must be safety. Although the other consequences are certainly important, they must not be given higher importance than safety. As well, the importance of safety must not be diluted due to inclusion of other consequence in a RBI program.

The following factors must be considered for each failure scenario during the consequence assessment:

- proximity to residential areas, highways, other industries,
- frequency and density of employee population,
- process fluid properties (with respect to flammability, toxicity, exposure limits and reactivity),
- potential for fatality or knockdown,
- potential for explosion, BLEVE, or vapour cloud,
- contained energy, and
- environmental impact.

The outcome of this consequence assessment must be utilized when determining risk (see Risk Determination below).

It is useful to assess the consequences of failure in both mitigated and unmitigated states. This will allow for a determination of the effectiveness and reliability of the mitigation used, and may highlight other forms of mitigation that would be more beneficial.

#### 7.4 Likelihood Assessment

In the context of RBI, the likelihood is the probability that a given failure event will occur. Often, likelihood will be measured as a frequency of failure events over a period of time (for example - events per year). Likelihood assessment is often considered the most difficult stage in determining risk. The owner must demonstrate a valid process based on historical data, an understanding of failure mechanisms, current operation, and recognition of possible future changes to compile all available data into a single value or category.

Each failure scenario must be assessed to determine the likelihood of it occurring. A number of factors must be considered to accomplish this as detailed below:

- Design Factor – considering design parameters versus operating parameters, design complexity, adequacy of design given current knowledge and codes.
- Process Factor – considering potential for upset and transient conditions, process stability, system cleanliness, operating history, operating procedures, operator skill, and the potential for failure of protective devices due to plugging or other concerns.
- Inspection Factor – considering the effectiveness of previous inspections based on damage expected, inspection techniques utilized, and accessibility.
- Damage Factor – considering results of previous inspections (direct and equivalent), known or expected damage mechanisms, rate of deterioration, and the date of the last inspection.
- Equipment Factor – considering the complexity of the equipment.

- Condition Factor – considering the physical condition of the equipment. The outcome of the likelihood assessment must be utilized when determining the risk (see Risk Determination below).

It is useful to assess the likelihood of failure in both mitigated and unmitigated states. This will allow for a determination of the effectiveness and reliability of the mitigation used and may highlight other forms of mitigation that would be more beneficial.

7.5 Risk Determination

Based on the previously obtained consequence and likelihood of failure, the risk level for each item can be assigned. The RBI program must define how risk is derived. Typically, consequence and likelihood are plotted against each other in a matrix with the location of the point falling into a range with a pre-defined risk index. A generic example of a risk matrix is shown below in Figure 1. The same matrix (or other method) must be used consistently for all risk assessments.

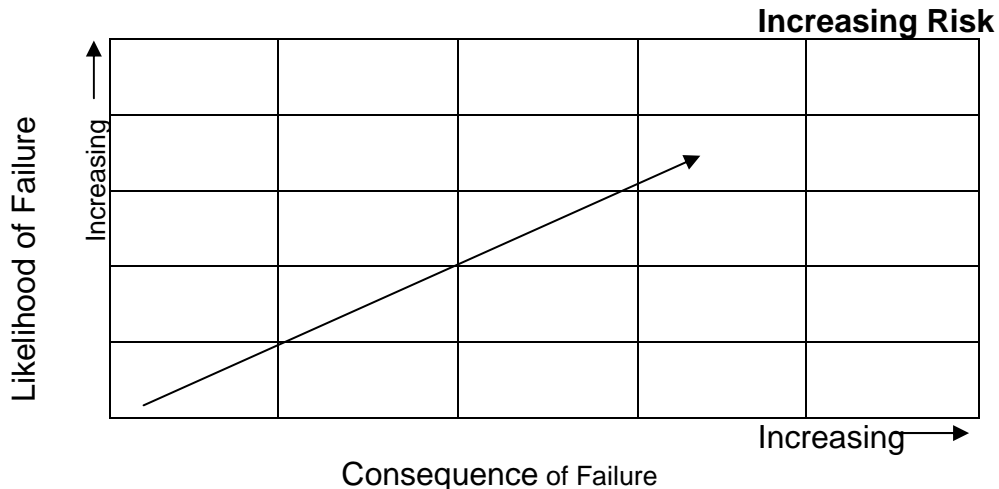


Figure 1. Generic Risk Matrix

In most cases, the highest resulting risk for each item based on the analysis should be used to determine the inspection and mitigation strategy. However, it may be necessary to consider more than one risk level, if different degradation modes that require different mitigation techniques are involved.

The critical step during this stage is the assignment of the level of risk to the matrix. The RBI program must define how each risk will be addressed in terms of inspection frequency, scope and other mitigation techniques. Typically this is achieved by segregating blocks in the matrix as having acceptable and unacceptable risks, and assigning required actions for each risk level. This is a policy decision that must come from upper management, within the owner company, as defined in the Owner-User Program.

## 7.6 Mitigation/Inspection Plan

A RBI program must have a mechanism for establishing a mitigation/inspection plan (including intervals) based on the risk level determined from the matrix. The plan must be appropriate to the level of risk and consider the expected failure modes and the key factors affecting risk. It must define inspection techniques to be used, specific regions to be examined and the nature of damage to be expected. Mitigation activities, as appropriate, are to be documented and validated as part of the plan. Examples may include (but are not limited to) the following:

- modify process,
- modify operating procedures,
- enhanced on-stream monitoring/inspection,
- upgrade alarm and detection systems. When credit taken for such for systems, particular attention must be given to the preventative maintenance programs and levels of instrumentation redundancy,
- replace or repair equipment,
- construct secondary containment or restraints, and
- control of ignition sources.

## 7.7 Re-assessment

The RBI program must include updating the risk assessments to ensure that the results are current with the most recent inspection, process, and maintenance information. The effectiveness of mitigation techniques must be validated. At minimum, RBI re-assessments are to be performed under the following conditions:

- after changes to the process, design, personnel, or other critical factors, or when new information becomes available that could impact the previous assessment,
- after new inspection data is obtained (after turnarounds),
- after a preset maximum time period has elapsed.

The specified maximum time period must be established and documented with respect to its suitability for ensuring that risk assessments remain current.

## REFERENCE PUBLICATIONS

API 510	Pressure Vessel Inspection Code*
API 570	Piping Inspection Code*
API 571	Damage Mechanisms Affecting Fixed Equipment in the Refining Industry
API 572	Inspection of Pressure Vessels*
API 580	Recommended Practice – Risk-Based Inspection*
API RP 750	Management of Process Hazards
363/2001	Contract Research Report. Best practice for risk-based inspection as a part of plant integrity management, prepared by TWI and Royal Sun Alliance Engineering for the Health and Safety Executive
OSHA 29CFR part 1910	Process Safety Management of Highly Hazardous Chemicals; Explosives and Blasting Agents; Final Rule
ABSA	Inspection & Servicing Requirements for Pressure Equipment

\* These documents are required for a RBI Program