Risk-Based Inspection Requirements for Pressure Equipment

AB–505

Edition 2, Revision 2 – Issued 2017-08-24

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FOREWORD

As provided for under Sections 11, 12 and 13 of the Pressure Equipment Safety Regulation (PESR), the Administrator in the pressure equipment discipline has established that ABSA document AB-505 "*Risk Based Inspection Programs for Pressure Equipment"* specifies information required by the Administrator from an owner that applies for risk-based inspection (RBI) to be included in their certificate of authorization permit as required under Section 11(3); and specifies features of a quality management system that may be acceptable to the Administrator, as provided for under Sections 12 and 13 of the PESR.

1.0 INTRODUCTION

This edition of AB-505 has been revised to reflect current API, ASME and other industry-recognized good engineering practices and to address improvements that were identified in the application of the previous edition of AB-505.

AB-505 establishes the requirements when risk-based inspection (RBI) is used to determine the inspection method(s) and frequency and degree of inspection of pressure equipment and pressure relief devices.

Alberta requirements governing inspection and servicing requirements for in-service pressure equipment are covered in AB-506. AB-506 identifies the conditions for using RBI and its application under the PESR, and is indispensable for the application of AB-505.

RBI can be very beneficial (increased reliability and safety; better understanding of risk; allows owner to better allocate resources; etc.). However, if not properly applied, the RBI process can focus attention away from items that are incorrectly assessed as having a low risk. This can result in hazardous situations.

An owner, who utilizes RBI to determine the type, frequency and degree of inspection of pressure equipment and pressure relief valve servicing intervals, must hold a quality management system certificate of authorization permit (CAP), per 11(3) of the PESR. The CAP must have risk-based inspection listed in the authorized scope. Effective use of RBI in this context requires formal management processes, detailed development and planning, and involvement of an experienced multi-disciplinary team (see section 6.2 Personnel). It should be noted that RBI is a continually changing, dynamic process. It is essential that the required resources are available to validate the RBI assessments throughout the full lifecycle of the equipment. For those programs with RBI in the scope of their CAP, the progressive grading system shown in AB-506 does not apply. However, owners must be aware of the following limitations:

- The maximum thorough RBI assessment interval is ten years;
- The maximum thorough inspection interval for directly fired power and heating boilers is four years;
- The maximum pressure relief valve servicing interval is ten years.

ABSA documents, such as AB-505 and AB-506, were developed with the close cooperation of owners and other stakeholders. Their input has been invaluable in compiling this document. In particular, we would like to acknowledge the following user groups that represent the industry sectors in Alberta:

- Alberta Refinery & Petrochemical Inspection Association (ARPIA)
- Upstream Chief Inspectors Association (UCIA)
- Contract Chief Inspectors Association (CCIA)
- Generation Utilities Advisory Committee (GUAC)
- Integrity Management Association Pulp Producers (IMAPP)

ABSA policy documents are living documents that are reviewed periodically to ensure that they are aligned with current industry practices. We would welcome any suggestions you have to improve AB-505. Please provide your comments to:

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Manager of Inspections
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The American Petroleum Institute (API) Codes and The National Board of Boiler and Pressure Vessel Inspectors (NB) publications are recognized and generally accepted as good engineering practice. Relevant information from these documents and other reference publications has therefore been considered in preparing AB-505 and other ABSA documents.

The NB and API publications are not adopted by the PESR. The application of these standards is established through their reference in applicable ABSA documents.

Owners are cautioned to ensure that current versions of the relevant good engineering practices, that are applicable to their specific industry sectors, are used to supplement the requirements covered in AB-505.

2.0 DEFINITIONS

For the purpose of AB-505, the following definitions apply. Relevant definitions, from the Alberta Safety Codes Act and Pressure Equipment Safety Regulation, are also included in this section.

ABSA – is the organization delegated by the Government of Alberta to administer the pressure equipment safety legislation under the Safety Codes Act.

Administrator – the Administrator in the pressure equipment discipline appointed under the Act; [PESR, 1(1)(b)].

Certificate of Authorization Permit (CAP) – a permit issued pursuant to section 44 of the Act authorizing a person to carry out the activities stated on the Certificate of Authorization Permit. [PESR 1(1)(g).

In-service – the period of time during the life of pressure equipment from the beginning of commissioning until disposal.

Integrity Operating Windows (IOW) – a set of limits used to determine the different variables that could affect the integrity and reliability of a process unit or system.

Integrity Management System (IMS) – a system for ensuring pressure equipment is designed, constructed, installed, operated, maintained, and decommissioned in accordance with the Pressure Equipment Safety Regulation. [PESR 1(1)(s)]

Management of Change (MOC) – a documented management system that ensures any physical or operational changes to pressure equipment, changes to procedures, and standards, and organizational changes do not adversely affect the integrity of the pressure system.

Owner – includes a lessee, a person in charge, a person who has care and control, and a person who holds out that the person has the powers and authority of ownership or who for the time being exercises the powers and authority of ownership. [SCA, 1(1)(v)]

Owner-user – an owner that has provided an Integrity Management System in accordance with the Pressure Equipment Safety Regulation and has been issued a quality management system Certificate of Authorization Permit under PESR Section 11(3).

PESR – Pressure Equipment Safety Regulation, Alberta Regulation 49/2006

Pressure equipment – a boiler, a fired-heater pressure coil, a thermal liquid heating system and other equipment designed to contain expansible fluid under pressure, including, but not limited to, pressure vessels, pressure piping systems and fittings, as defined in the regulations.[SCA, 1(1)(y)]

Public occupancy – is defined as any facility where members of the general public are likely to be present. This would include schools, offices, shopping malls, stores, arenas, pools, restaurants, hotels, etc.

Quality Manual – as used in this document, means a written description of the quality management system. An owner, who has implemented, or will implement, a quality management system, has the discretion to determine the format of the document. It is not necessary for the written description of the quality management system to be presented as a stand-alone "quality manual".

Risk-based Inspection Program (RBIP) – a risk-based inspection program that has been reviewed and accepted by ABSA and is identified under the Authorized scope of an owner-user's Alberta Quality Management Certificate of Authorization Permit, issued per section 11(3) of the PESR.

Risk-based Inspection (RBI) – a risk assessment and management process that is focused on loss of containment of pressurized equipment in processing facilities, due to material deterioration. These risks are managed primarily through equipment inspection (see API RP 580).

Risk – the product of the probability of the failure of an item and the expected consequences should that failure occur.

3.0 GOVERNING LEGISLATION

Legislation that governs the pressure equipment discipline includes the following:

- *Safety Codes Act*
- *Pressure Equipment Exemption Order* (Alberta Regulation 56/2006)
- *Pressure Equipment Safety Regulation* (Alberta Regulation 49/2006)
- *Power Engineers Regulation* (Alberta Regulation 85/2003)
- *Pressure Welders Regulation* (Alberta Regulation 169/2002)
- *Administrative Items Regulation* (Alberta Regulation 16/2004)

Note: The Pressure Equipment Safety Regulation User Guide (AB-516) provides valuable information to assist stakeholders in meeting the requirements of the Pressure Equipment Safety Regulation and in assuring the safe operation of their pressure equipment.

4.0 REFERENCED PUBLICATIONS

Section 6 of the PESR includes the codes, standards and bodies of rules that are declared in force with respect to pressure equipment in Alberta. National Board (NB), American Petroleum Institute (API) and ASME Post Construction Committee (PCC) codes and standards, and similar publications, are not declared in force by the PESR. Their application is established, through reference, in this document and other ABSA policy documents.

API RP 580/581 and ASME PCC-3 are widely used and recognized generally accepted codes and standards governing risk-based inspection. Information from these publications, and other relevant good engineering practices, has been used in preparation of the AB-505.

Documents issued by the Administrator

The following referenced ABSA documents have been approved by the Administrator to establish the requirements that must be met for in-service pressure equipment under the PESR. The requirements documents shown below, and other ABSA requirements documents and guidelines, are available on the www.absa.ca website.

AB-506 Inspection & Servicing Requirements for In-Service Pressure Equipment
This document defines requirements for the inspection of pressure equipment and servicing of pressure relief devices.

AB-512 *Owner-User Pressure Equipment Integrity Management Requirements*
This specifies quality management system requirements for owners who are required to hold a Certificate of Authorization Permit under PESR Section 11(3).

AB-513 *Pressure Equipment Repair and Alteration Requirements*
This covers inspection and certification and other requirements for repairs and alterations to pressure equipment.

AB-515 *Quality Management System Requirements for Integrity Assessment Organizations*
This specifies quality management system requirements for inspection organizations that are required to hold a Certificate of Authorization Permit for integrity assessment under PESR Section 11(2).

AB-518 *Pressure Piping Construction Requirements Document*
This document specifies quality management system requirements for companies that are required to hold a Certificate of Authorization Permit to construct pressure piping under the PESR.

AB-521 Requirements for Engineered Pressure Enclosures
This specifies the requirements that must be met for the design, fabrication, installation and removal of Engineered Pressure Enclosures.

AB-524 Pressure Relief Devices Requirements
This specifies the quality management system requirements for companies that are required to hold a Certificate of Authorization Permit to service, repair, set or seal a pressure relief valve.

AB-525 Overpressure Protection Requirements for Pressure Vessel and Piping
This document defines Alberta requirements that must be met for overpressure protection of pressure piping and/or pressure vessels.

AB-526 *In-Service Pressure Equipment Inspector Certification*
This establishes the requirements for certification of in-service pressure equipment inspectors (ISI).

Referenced Codes and Standards and other Recognized and Generally Accepted Good Engineering Practices:

ASME PCC–3 – Inspection Planning Using Risk-Based Methods

API RP 580 – *Risk-Based Inspection*
API RP 581 – *Risk-Based Inspection Technology*

API RP 750 – Management of Process Hazards

5.0 GENERAL

RBI may be applied in any industry in Alberta, provided the requirements of AB-505 and AB-506 are met.

Pressure equipment, for process applications installed in Alberta, covers a broad range of facilities from major petrochemical plants, pulp mills, and power utilities to small oil and gas processing facilities, commercial facilities and other applications. The extent of an owner-user's integrity management system and the RBI processes needed to achieve an effective and practical RBI program will therefore vary considerably and will also depend on the equipment that is to be included in the RBI assessment, and whether the risk-based inspection program is authorized under the PESR (refer to section 6 of this document).

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 probability of the failure of the item, and the expected consequences should that failure occur.

In general, the risk is determined in accordance with a defined, logical and consistent method. The probability and consequences of failure are determined for each item through a qualitative assessment or, in some cases, a more rigorous 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 probability 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 probability and high consequence of failure will be identified as requiring the most attention from inspection and other mitigation techniques. Similarly, items with a low probability 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 probability 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.

It cannot be over-emphasized that an effective RBI program must be carefully planned and controlled, and requires skilled, knowledgeable personnel to operate it 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.

In addition to safety, a comprehensive RBI program will typically consider environmental and economic risks (business interruption, equipment damage). Since ABSA is concerned with the safety and integrity of pressure equipment, this document primarily addresses safety and environmental considerations only.

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. Persons wishing to implement a formal risk-based inspection program should refer to the referenced documents and to the various publications and guidance information that is available, some of which is listed below:

- *API RP 580 Risk-Based Inspection* which is oriented toward the Hydrocarbon and Chemical Process Industries.
- *API 581 Risk-based Inspection Base Resource Document*
  This provides details on RBI methodology that has all of the key elements defined in API RP 580.
- *ASME PCC – 3 Inspection Planning Using Risk-Based Methods*
  This is based on API RP 580 and contains additions and improvements to enhance its suitability for broader industry sectors (e.g. refineries and petrochemical facilities, oil and gas processing, pulp and paper, power generation).

- 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 also 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.

6.0 REQUIREMENTS FOR AN AUTHORIZED RISK-BASED INSPECTION PROGRAM

The following establishes the requirements that must be met when RBI is used to determine the appropriate thorough inspection intervals and the type and extent of future inspections/examinations for pressure equipment, as well as the servicing intervals for pressure relief devices. Owners who use this option must hold a CAP, per 11(3) of the PESR, which has risk-based inspection listed in its authorized scope.

In order for risk-based inspection to be included in the authorized scope of an owner-user's CAP, the RBI process must be thoroughly documented in accordance with API RP 580 or PCC-3 and be clearly defined in the quality management system documentation. The owner must demonstrate that the risk assessment and inspection planning processes used are being implemented effectively and the RBI program must be reviewed and accepted by ABSA.

The use of a less-than-fully-quantitative (i.e. not fully API 581, Section 7 compliant) risk-based approach to determine the pressure relief valve (PRV) maximum servicing intervals that do not exceed the AB-506 maximum servicing intervals is acceptable. This approach should be described in the owner's risk-based inspection procedures.

An owner, who wishes to exceed the AB-506 maximum servicing intervals for PRVs through a risk-based inspection program, shall utilize API 581 (Section 7) as the foundation of their risk-based program, where the servicing interval is commensurate with the inherent risk of the relief device. The risk assessment shall be quantitative in nature and shall consider the valve failing to open, as well as premature leakage. The owner's pressure relief device RBI program shall also include aspects of API 576 for condition based inspection and monitoring, which contributes into the determination of the risk.

The owner must have the required resources, structure and management processes to ensure the RBI is appropriate. This would normally require that they have suitable in-house resources and have operated under an owner-user CAP for at least three years, and have had at least one satisfactory CAP renewal audit.

The pressure equipment to be managed must be clearly identified. Consideration should be given to the impact on the auxiliary equipment not included in the RBI scope.

If a consultant is used to assist with RBI implementation 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 assisting 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.

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, consistent, 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 (see appendix A). 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 specify how hazards are defined for each pressure item, how the probability and consequences of failure are established, and how this is used to determine risk level and inspection intervals. Appendix A gives an overview of the following key elements of the procedure that must be addressed and provides further guidance:

1. Data collection
2. Hazard/degradation mode identification
3. Corrosion control documents
4. Consequence assessment
5. Probability assessment
6. Risk determination
7. Mitigation/Inspection plan/strategy
8. Management of Change
9. Integrity operating windows
10. Re-assessment

6.2 RBI team/Personnel

RBI and inspection planning requires a range of technical input and perspectives from different disciplines and therefore is best undertaken by a team. The number of team members and the team composition will vary, depending on the complexity of the installation. Typically, the involvement of people knowledgeable and experienced in corrosion, materials, maintenance, process and operation are necessary.

The team should have a team leader with the authority to manage the team and the responsibility for 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. However, the owner must have a suitable structure and organization to review and evaluate/validate RBI results.

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/facilitator
- Chief Inspector
- equipment inspectors
- a corrosion specialist with sufficient qualifications and experience to understand the process, predict failure mechanisms and identify limitations in inspection techniques
- process specialists
- operations specialists
- maintenance specialists
- management
- risk assessment personnel
- environment and safety personnel
- financial and business personnel
- A knowledgeable person operating the RBI computer model

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 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 being 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,
- mitigated risk levels, and
- documented sign off and acceptance of the RBI assessment by the responsible inspector.

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 any other new information. This documentation will be required during internal audits, as well as ABSA audits, of the RBI program.

6.4 Pre-commissioning Inspections

A pre-commissioning inspection, per AB-506, must be completed on each pressure equipment item.

A robust pre-commissioning program is of particular importance, since this is when the initial risk assessment of new installations should be made.

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 probability or consequences of pressure equipment failure.

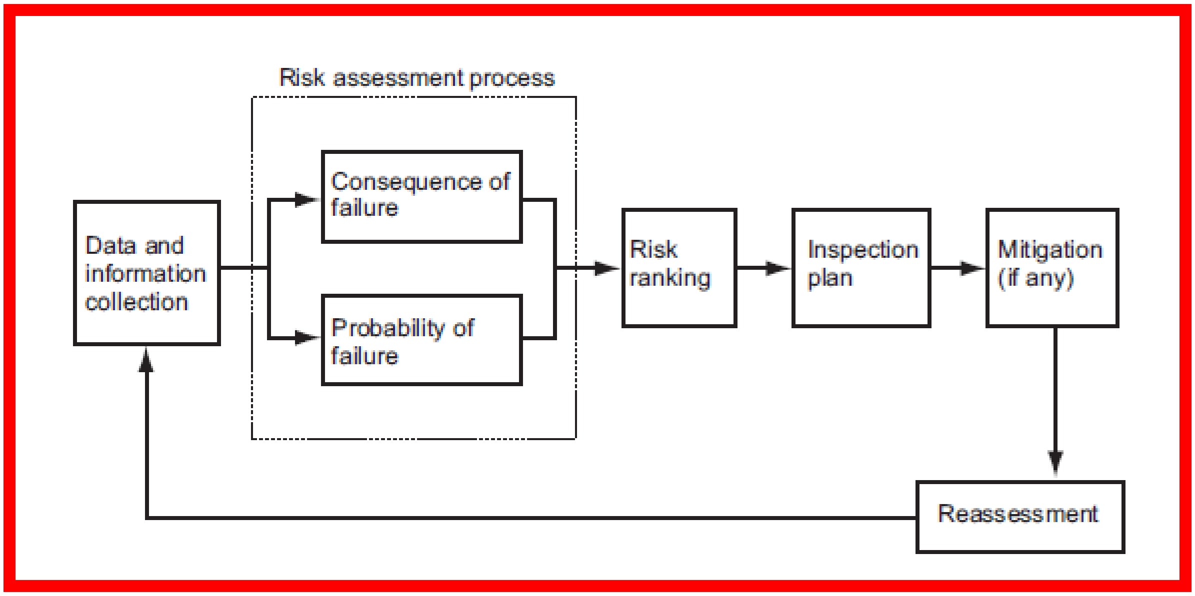
Operating within the operating boundaries is critical to the validity of the risk analysis, as well as good operating practice. Key process parameters (such as IOWs) shall be monitored to determine whether operations are maintained within the operating boundaries.

Any RBI program shall be linked to the management of change (MOC) process the owner’s IMS is required to have as per the AB-512 requirements.

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.

A comprehensive management of change program is crucial and must be adequately described in the owner's quality manual that is on file with ABSA. A comprehensive MOC process must cover items such as: changes to feed stock, changes in operating conditions, equipment modifications or additions, plant changes, abnormal operating or process conditions, personnel changes, etc.

APPENDIX A: KEY ELEMENTS OF A RBI PROCEDURE



The following discusses 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/Data Collection
- Hazard/Degradation Mode Identification,
- Consequence Assessment,
- Probability 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 exactly, provided that all essential elements are addressed. Much more detail regarding risk assessment is available in some of the referenced documents, particularly API RP 580.

1. System Definition/Data Collection

This stage involves the collection of pertinent data to be used in assessing the probability and consequence of failure for each pressure item. It identifies what has been and what will be assessed, and what data will be collected.

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

- operating pressure and temperature (including transient and upset conditions),
- process fluid properties (including flammability, toxicity, and reactivity),
- process change/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.

2. Hazard/Degradation Mode Identification

Once the background information is in place, the hazards must be identified. This involves identifying equipment specific potential and credible degradation modes and damage mechanisms, using the inspection and process data and industry experience. 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.

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

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.

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 direct and indirect financial costs. The focus of any RBI program applied to pressure equipment must be safety driven, which is the intent of this document.

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 the inclusion of other consequences in a RBI program.

As a minimum, the following factors must be considered (more may be required) for each failure scenario identified during the consequence assessment:

- expected failure modes – pinhole, corrosion hole, rupture, crack, etc.
- 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, boiling liquid expanding vapor explosion (BLEVE), or vapor 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.

4. Probability Assessment

In the context of RBI, probability is the likelihood that a given failure event will occur. Probability is often measured as a frequency of failure events over a period of time (for example - events per year). Probability 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 probability 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 internal and external condition of the equipment.

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

It is useful to assess the probability 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.

5. Risk Determination

Based on the previously obtained consequence and probability of failure, the risk level for each item can be assigned. The RBI program must define how risk is derived. Typically, consequence and probability 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.

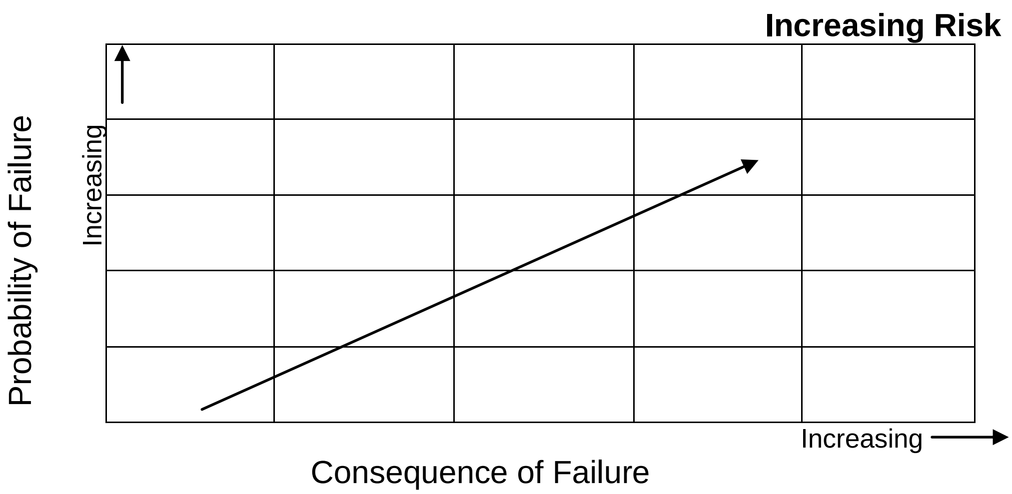


Figure 1. Generic Risk Matrix

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.

6. Mitigation/Inspection Plan/Strategy

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 key factors affecting risk. It must define the 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.

The mitigation activities(s) selected must address the degradation mechanism. Examples of mitigation activities may include (but are not limited to) the following:

- Inspect the equipment – internally, on stream in lieu of internally, externally
- modify process,
- modify operating procedures,
- enhanced on-stream monitoring/inspection,
- upgrade alarm and detection systems. When credit is 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. 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, the RBI re-assessments are to be performed under the following conditions:

- after changes to the process, the design 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. Per AB-506, the maximum time period cannot exceed ten years.

7.0 REVISION LOG

Edition	Rev #	Date	Description
2	0	2016-02-12	Updates throughout
2	1	2016-09-30	Editorial revisions, page ii and page 2
2	2	2017-08-24	• Foreword revised. • Certificate of Authorization Permit definition revised. • Revised title of AB-515 to align with the current version of AB-515. • Clarification regarding the acceptability and limitations for RBI programs to determine PRV service intervals.