Risk-Based Inspection

Downstream Segment

API RECOMMENDED PRACTICE 580
SECOND EDITION, NOVEMBER 2009

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety datasheet.

Neither API nor any of API's employees, subcontractors, consultants, or other assigns make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or utility of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication, or represent that its used would not infringe upon privately owned rights.

Classified areas may vary depending on the location, conditions, equipment, and substances involved in any given situation. Users of this recommended practice (RP) should consult with the appropriate authorities having jurisdiction.

Users of this RP should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgement should be used in employing the information contained herein.

Where applicable, authorities having jurisdiction should be consulted.

Work sites and equipment operations may differ. Users are solely responsible for assessing their specific equipment and premises in determining the appropriateness of applying the RP. At all times users should employ sound business, scientific, engineering, and judgement safety when using this RP.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Foreword

This recommended practice (RP) is intended to provide guidance on developing a risk-based inspection (RBI) program for fixed equipment and piping in the hydrocarbon and chemical process industries. It includes:

— what is RBI,

— what are the key elements of RBI,

— how to implement an RBI program,

— how to sustain an RBI program.

It is based on the knowledge and experience of engineers, inspectors, risk analysts, and other personnel in the hydrocarbon and chemical industry.

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

This RP is intended to supplement API 510, API 570, and API 653. These API inspection codes and standards allow an owner/user latitude to plan an inspection strategy and increase or decrease the code designated inspection frequencies and activities based on the results of an RBI assessment. The assessment must systematically evaluate both the POF and the associated consequence of failure (COF). The POF assessment should be evaluated by considering all credible damage mechanisms. Refer to the appropriate code for other RBI assessment requirements. This RP is intended to serve as a guide for users in properly performing such an RBI assessment.

The information in this RP does not constitute and should not be construed as a code of rules, regulations, or minimum safe practices. The practices described in this publication are not intended to supplant other practices that have proven satisfactory, nor is this publication intended to discourage innovation and originality in the inspection of hydrocarbon and chemical facilities. Users of this RP are reminded that no book or manual is a substitute for the judgment of a responsible, qualified inspector or engineer.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 1220 L Street, NW, Washington, DC 20005.

Suggested revisions are invited and should be submitted to the director, Standards Department, American Petroleum Institute, 1220 L Street, NW, Washington DC 20005, standards@api.org.

Contents

Page

Page

Introduction

This recommended practice (RP) provides information on using risk analysis to develop an effective inspection plan. Inspection planning is a systematic process that begins with identification of facilities or equipment and culminates in an inspection plan. Both the probability [1] of failure and the consequence of failure (COF) should be evaluated by considering all credible damage mechanisms that could be expected to affect the facilities or equipment. In addition, failure scenarios based on each credible damage mechanism should be developed and considered.

The output of the inspection planning process conducted according to these guidelines should be an inspection plan for each equipment item analyzed that includes:

a) inspection methods that should be used,

b) extent of inspection (percent of total area to be examined or specific locations),

c) inspection interval or next inspection date (timing),

d) other risk mitigation activities,

e) the residual level of risk after inspection and other mitigation actions have been implemented.

The RBI plan produced according to the guidance herein, combined with a comprehensive set of integrity operating windows for each process unit and a rigorous MOC program should provide the basis for sound management of the integrity of fixed equipment in the refining and petrochemical process industry.

RBI is synonymous with risk-prioritized inspection, risk-informed inspection and with inspection planning using risk-based methods.

[1] Likelihood is sometimes used as a synonym for probability; however, probability is used throughout this standard for consistency.

Risk-Based Inspection

1 Purpose

1.1 General

The purpose of this document is to provide users with the basic elements for developing, implementing, and maintaining a risk-based inspection (RBI) program. It provides guidance to owners, operators, and designers of pressure-containing equipment for developing and implementing an inspection program. These guidelines include means for assessing an inspection program and its plan. The approach emphasizes safe and reliable operation through risk-prioritized inspection. A spectrum of complementary risk analysis approaches (qualitative through fully quantitative) can be considered as part of the inspection planning process. RBI guideline issues covered include an introduction to the concepts and principles of RBI for risk management; and individual sections that describe the steps in applying these principles within the framework of the RBI process include:

a) understanding the design premise;

b) planning the RBI assessment;

c) data and information collection;

d) identifying damage mechanisms and failure modes;

e) assessing probability of failure (POF);

f) assessing COF;

g) risk determination, assessment, and management;

h) risk management with inspection activities and process control;

i) other risk mitigation activities;

j) reassessment and updating;

k) roles, responsibilities, training, and qualifications;

l) documentation and recordkeeping.

The expected outcome from the application of the RBI process should be the linkage of risks with appropriate inspection, process control or other risk mitigation activities to manage the risks. The RBI process is capable of generating:

1) a ranking by relative risk of all equipment evaluated;

2) a detailed description of the inspection plan to be employed for each equipment item, including:

    — inspection method(s) that should be used [e.g. visual, ultrasonic (UT), radiography, wet flourescent magnetic particle];

    — extent of application of the inspection method(s) (e.g. percent of total area examined or specific locations);

    — timing of inspections/examinations (inspection intervals/due dates);

— risk management achieved through implementation of the inspection plan;

3) a description of any other risk mitigation activities [such as repairs, replacements or safety equipment upgrades, equipment redesign or maintenance, integrity operating windows (IOWs), and controls on operating conditions];

4) the expected risk levels of all equipment after the inspection plan and other risk mitigation activities have been implemented;

5) identification of risk drivers.

1.2 RBI Benefits and Limitations

The primary work products of the RBI assessment and management approach are plans that address ways to manage risks on an equipment level. These equipment plans highlight risks from a safety/health/environment perspective and/or from an economic standpoint. RBI plans should include cost-effective actions along with a projected risk mitigation.

Implementation of these plans provides one of the following:

a) an overall reduction in risk for the facilities and equipment assessed,

b) an acceptance/understanding of the current risk.

The RBI plans also identify equipment that does not require inspection or some other form of mitigation because of the acceptable level of risk associated with the equipment's current operation. In this way, inspection and maintenance activities can be focused and more cost effective. This often results in a significant reduction in the amount of inspection data that is collected. This focus on a smaller set of data should result in more accurate information. In some cases, in addition to risk reductions and process safety improvements, RBI plans may result in cost reductions.

RBI is based on sound, proven risk assessment and management principles. Nonetheless, RBI will not compensate for:

c) inaccurate or missing information,

d) inadequate designs or faulty equipment installation,

e) operating outside the acceptable IOWs,

f) not effectively executing the plans,

g) lack of qualified personnel or teamwork,

h) lack of sound engineering or operational judgment.

1.3 Using RBI as a Continuous Improvement Tool

Utilization of RBI provides a vehicle for continuously improving the inspection of facilities and systematically reducing the risk associated with pressure boundary failures. As new data (such as inspection results and industry experiences with similar processes) becomes available or when changes occur (e.g. operating conditions), reassessment of the RBI program can be made that will provide a refreshed view of the risks. Risk management plans should then be adjusted appropriately.

RBI offers the added advantage of identifying gaps or shortcomings in the effectiveness of commercially available inspection technologies and applications. In cases where technology cannot adequately and/or cost-effectively mitigate risks, other risk mitigation approaches can be implemented. RBI should serve to guide the direction of inspection technology development, and hopefully promote a faster and broader deployment of emerging inspection technologies as well as proven inspection technologies that may be available but are underutilized.

1.4 RBI as an Integrated Management Tool

RBI is a risk assessment and management tool that addresses an area of risk management not completely addressed in other organizational risk management efforts such as process hazards analyses (PHA), IOWs or reliability centered maintenance (RCM). Integration of these risk management efforts, including RBI, is key to the success of a risk management program.

RBI produces inspection and maintenance plans for equipment that identify the actions that should be taken to provide reliable and safe operation. The RBI effort can provide input into an organization's annual planning and budgeting that define the staffing and funds required to maintain equipment operation at acceptable levels of performance and risk.

RBI needs to be integrated with a management system for defining and maintaining IOWs as well as a robust management of change (MOC) process as a basis for managing and controlling damage mechanisms in fixed equipment.

2 Scope

2.1 Industry Scope

Although the risk management principles and concepts that RBI is built on are universally applicable, this RP is specifically targeted at the application of RBI in the hydrocarbon and chemical process industry.

2.2 Flexibility in Application

Because of the broad diversity in organizations' size, culture, federal and/or local regulatory requirements, this RP offers users the flexibility to apply the RBI methodology within the context of existing corporate risk management practices and to accommodate unique local circumstances. The document is designed to provide a framework that clarifies the expected attributes of a quality risk assessment without imposing undue constraints on users. This RP is intended to promote consistency and quality in the identification, assessment, and management of risks pertaining to material deterioration, which could lead to loss of containment.

Many types of RBI methods exist and are currently being applied throughout industry. This document is not intended to single out one specific approach as the recommended method for conducting an RBI effort. The document instead is intended to identify and clarify the essential elements of an RBI analysis and program.

2.3 Mechanical Integrity Focused

The RBI process is focused on maintaining the mechanical integrity of pressure equipment items and minimizing the risk of loss of containment due to deterioration. RBI is not a substitute for a PHA or hazard and operability assessment (HAZOP). Typically, PHA risk assessments focus on the process unit design and operating practices and their adequacy given the unit's current or anticipated operating conditions. RBI complements the PHA by focusing on the mechanical integrity related damage mechanisms and risk management through inspection. RBI also is complementary to RCM programs in that both programs are focused on understanding failure modes, addressing the modes and therefore improving the reliability of equipment and process facilities.

2.4 Equipment Covered

The following types of equipment and associated components/internals are covered by this document.

a) Pressure Vessels—All pressure containing components.

b) Process Piping—Pipe and piping components.

c) Storage Tanks—Atmospheric and pressurized.

d) Rotating Equipment—Pressure containing components.

e) Boilers and Heaters—Pressurized components.

f) Heat exchangers (shells, floating heads, channels, and bundles).

g) Pressure-relief devices.

2.5 Equipment Not Covered

The following equipment is not covered by this document:

a) instrument and control systems,

b) electrical systems,

c) structural systems,

d) machinery components (except pump and compressor casings).

However, these systems and components may be covered by other types of RBI or risk assessment work processes such as RCM.

2.6 Target Audience

The primary audience for this RP is inspection and engineering personnel who are responsible for the mechanical integrity and operability of equipment covered by this RP. However, while an organization's inspection/materials engineering group may champion the RBI initiative, RBI is not exclusively an inspection activity. RBI requires the involvement of various segments of the organization such as engineering, maintenance and operations. Implementation of the resulting RBI product (e.g. inspection plans, replacement/upgrading recommendations, other mitigation activities, etc.) may rest with more than one segment of the organization. RBI requires the commitment and cooperation of the total operating organization. In this context, while the primary audience may be inspection and materials engineering personnel, other stakeholders who are likely to be involved should be familiar with the concepts and principles embodied in the RBI methodology to the extent necessary for them to understand the risk assessment process and to be able to accept the results.

3 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Publication 510, *Pressure Vessel Inspection Code: Inspection, Rating, Repair, and Alteration*

API Publication 570, *Piping Inspection Code: Inspection, Repair, Alteration, and Rerating of In-service Piping Systems*

API Recommended Practice 571, *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

API Standard 579-1/ASME [1] FFS-1, *Fitness-For-Service*

API Recommended Practice 581, *Risk-Based Inspection Technology*

API Standard 653, *Tank Inspection, Repair, Alteration, and Reconstruction*

API Recommended Practice 752, *Management of Hazards Associated With Location of Process Plant Buildings*

API Recommended Practice 941, *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*

AICHE [2], *Dow's Fire and Explosion Index Hazard Classification Guide*, 1994

ASME PVRC Project 99-IP-01, *A Comparison of Criteria For Acceptance of Risk*, February 16, 2000

EPA 58 *FR* 54190 (40 *CFR* Part 68) [3], *Risk Management Plan (RMP) Regulations*

ISO Guide 73 [4], *Risk Management Vocabulary*

OSHA 29 *CFR* 1910.119 [5], *Process Safety Management of Highly Hazardous Chemicals*

4 Terms, Definitions, Acronyms and Abbreviations

4.1 Terms and Definitions

For purposes of this RP, the following terms, definitions, acronyms, and abbreviations shall apply.

4.1.1
absolute risk
An ideal and accurate description and quantification of risk.

4.1.2
acceptable risk
A level of risk that is acceptable to the owner-user.

4.1.3
as low as reasonably practical
ALARP
A concept of minimization that postulates that attributes (such as risk) can only be reduced to a certain minimum under current technology and with reasonable cost.

---

1 ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.
2 American Institute of Chemical Engineers, Center for Chemical Process Safety, 3 Park Avenue, 19th Floor, New York, New York 10016, www.aiche.org/ccps.
3 U.S. Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue, Washington, DC 20460, www.epa.gov.
4 International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.
5 U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Avenue, NW, Washington, DC 20210, www.osha.gov.