

API 580 Practice Exam (By the Chapter)

Part 3 (Chapter 13 – 18**)

110+ Practice Questions (20 on real exam)

For this reason, it is recommended that you follow these 10 CRITICAL STUDY TIPS:

1. Take the one-week exam preparation course offered by PEDD and use the E-Library
2. Plan your application & study several (4 or more) months in advance of the 580 exam
3. A final day PEDD Course score will determine how much added study time you need
4. Follow recommendations in this study guide carefully and track your own study time
5. Study time depends on English skills (**average English skills = 125+ hrs. of study**)
6. Review Chapters (1 – 17) individually & answer practice exam questions afterwards
7. Repeat review of the 17 chapters (at least 4 – 5 times) & note test score improvements
8. **Priority of Study** is listed on next page along with three priorities chapter by chapter
9. After you have completed the full review chapter by chapter each time, take the exam
10. When you can honestly score 80%+ taking E-Library practice exams, you are ready

1st (Top) Priority ... 2nd Priority ... 3rd (Lowest) Priority

API 580 Chapter Title	API 580 Chapter	# Exam Q's	Sections to Review	Priority of Study	Practice Exam Questions
Risk Management with Inspection Activities	13	8	All	1	_____ of 45
Other* Risk Mitigation Activities (*Non-inspection)	14	3	All	3	_____ of 20
Reassessment and Updating RBI Assessments	15	3	All	3	_____ of 15
Roles, Responsibilities, Training, and Qualifications	16	3	All	3	_____ of 15
RBI Documentation and Recordkeeping	17	3	All	3	_____ of 15
**Summary of RBI Pitfalls (CH 18 = NOT ON API 580 EXAM)	**18	N/A	N/A	N/A	**Not on exam
<u>PART 3 of 3</u>	Ch 13-17	20 of 70 = 28%	As listed above!	As listed above!	_____ of 110

API 580 Study Guide Part 3 → Chapters 13 through 18

13 Risk Management with Inspection Activities

13.1 Managing Risk by Reducing Uncertainty through Inspection

In previous sections, it has been mentioned that risk can be managed by inspection. Obviously, inspection does not arrest or mitigate damage mechanisms or in and of itself it does not reduce risk, but the information gained through effective inspection can better quantify the actual risk.

Impending failure of pressure equipment is not avoided by inspection activities unless the inspection precipitates* (*causes to happen) risk mitigation activities that CHANGE POF.

Inspection serves to identify, monitor, and measure the damage mechanism(s).

Inspection is invaluable input in the prediction of when the damage will reach a critical point.

Correct application of inspections will improve the user's ability to predict the damage mechanisms and rates of deterioration. The better the predictability, the less uncertainty there will be as to when a failure may occur. Mitigation (repair, replacement, changes, etc.) can then be planned and implemented prior to the predicted failure date.

The reduction in uncertainty and increase in predictability through inspection translate directly into a better estimate of the probability of a failure and a reduction in the calculated risk.

However, users should be diligent* (*careful and determined) to assure that temporary inspection alternatives, in lieu of more permanent risk reductions, are actually effective. The foregoing* (*previous statement) does not imply that risk-based inspection plans and activities are always the answer to monitoring degradation and therefore reducing risks associated with pressure equipment. Some damage mechanisms are very difficult or impossible to monitor with just inspection activities (e.g. metallurgical deterioration that may result in brittle fracture, many forms of stress corrosion cracking, and even fatigue).

Other damage mechanisms precipitated by short-term, event-driven operating changes can happen too fast to be monitored with normal inspection plans, be they risk-based, condition-based or time-based. Hence the need for establishing and implementing a comprehensive program for IOWs, along with adequate communications to inspection personnel when deviations occur and a rigorous MOC program for changes from established parameters.

Risk mitigation (by the reduction in uncertainty) achieved through inspection presumes that the organization will act on the results of the inspection in a timely manner.

Risk mitigation is not achieved if inspection data that are gathered are not properly analyzed and acted upon where needed.

The quality of the inspection data and the analysis or interpretation will greatly affect the level of risk mitigation.

Proper inspection methods and data analysis tools are therefore critical.

Review this section first and then proceed to Practice Exam questions for Section 13.1

API 580 Sect. 13.1 Exam Qs (Risk Management with Inspection Activities)

13.1 ... Managing Risk by Reducing Uncertainty thru Inspection

1. Regarding risk management, inspection alone does not arrest or mitigate damage mechanisms or reduce risk, but the information gained through effective inspection can:

- A) Better quantify the actual risk
- B) Precisely identify the actual risk
- C) Better quantify the absolute risk
- D) Precisely identify the absolute risk

2. Regarding risk management, impending failure of pressure equipment is not avoided by inspection activities unless the inspection causes what to happen (or results in)?

- A) Risk mitigation activities that change the COF
- B) Risk mitigation activities that change the POF
- C) Supplemental inspection activities that better identify the POF
- D) Supplemental inspection activities that better identify the POF & result in a change to COF

3. Regarding risk management, inspection serves all of the following purposes EXCEPT:

- A) To correctly identify the damage mechanism
- B) To adequately monitor the damage mechanism
- C) To adequately measure the damage mechanism
- D) To prevent failures caused by the damage mechanism

4. Regarding risk management, inspection is invaluable input in the prediction of when the damage will:

- A) Result in a catastrophic failure mode
- B) Result in a loss of containment
- C) Reach a critical point
- D) None of these can be determined by inspection

5. Regarding risk management with inspection activities, the correct application of inspections will improve the API 580 user's ability:

- A) To plan and implement mitigation after predicted failure dates
- B) To predict the damage mechanisms and rates of deterioration
- C) To determine failure dates with greater probability
- D) To determine failure dates with greater precision

API 580 Sect. 13.1 Exam Qs (Risk Management with Inspection Activities)

13.1 ... Managing Risk by Reducing Uncertainty thru Inspection

6. Regarding risk management with inspection activities, the reduction in uncertainty and increase in predictability through inspection translate directly into a better estimate of the:

- A) POF and a reduction in actual risk
- B) COF and a reduction in actual risk
- C) POF and a reduction in calculated risk
- D) COF and a reduction in calculated risk

7. RBI plans & activities are not always the answer to monitoring degradation resulting in the risk reduction associated with pressure equipment. All of these damage mechanisms listed are very difficult or impossible to monitor with inspection activities alone EXCEPT:

- A) Metallurgical deterioration that may result in instantaneous failure (such as brittle fracture)
- B) Forms of localized pitting that can result in significant wall loss and loss of containment
- C) Forms of stress corrosion cracking as identified in API 571
- D) Forms of fatigue failure as identified in API 571

8. Regarding risk management with inspection activities, damage mechanisms caused by these types of operating changes can happen too fast to be monitored with the normal risk-based/condition-based/or time-based inspection plans?

- A) Short-term, external event-driven operating changes
- B) Long-term, external event-driven operating changes
- C) Long-term, event-driven operating changes
- D) Short-term, event-driven operating changes

9. Regarding risk management with inspection activities, damage mechanisms caused by short-term, event-driven operating changes can happen too fast to be monitored with:

- A) Normal risk-based, condition-based or time-based inspection plans
- B) Optimized risk-based or condition-based inspection plans
- C) Normal risk-based or time-based inspection plans
- D) Optimized risk-based inspection plans

10. Regarding risk management with inspection activities, because damage mechanisms caused by short-term, event-driven operating changes can happen too fast to be monitored with the normal risk-based/condition-based/or time-based inspection plans, all of the items below are recognized by API 580 as needed to properly manage risk EXCEPT:

- A) Establishing and implementing a comprehensive program for IOWs
- B) Establish adequate communications to inspection personnel when process deviations occur
- C) Establish and implement a rigorous MOC program for changes from established parameters
- D) Establish and implement operating windows & procedures where deviations are not allowed

API 580 Sect. 13.1 Exam Qs (Risk Management with Inspection Activities)

13.1 ... Managing Risk by Reducing Uncertainty thru Inspection

11. Risk mitigation (by the reduction in uncertainty) achieved through inspection presumes that the organization will:

- A) Act on the results of the inspection immediately
- B) Act on the results of the inspection in a timely manner
- C) Act on the results of the inspection before the need arises for mitigation
- D) Act on the results of the inspection before the need arises due to loss of containment

12. Regarding risk management with inspection, if inspection data that are gathered are not properly analyzed and acted upon where needed, what will likely be the result?

- A) The likely result will be a loss of containment
- B) The likely result will be a significant increase in the absolute risk
- C) The likely result will be that the risk mitigation will not be achieved
- D) The likely result will be a possible loss of containment & risk mitigation will not be achieved

13. Regarding risk management with inspection, the quality of the inspection data and the analysis or interpretation will greatly affect the level of:

- A) Actual risk
- B) Absolute risk
- C) Unmitigated risk
- D) Risk mitigation

14. Regarding risk management with inspection, because the quality of the inspection data and the analysis or interpretation will greatly affect the level of risk mitigation, which of the following items are critical?

- A) Proper inspection methods and data analysis tools
- B) Strictly applied inspection and risk analysis procedures
- C) Strictly applied inspection methods and procedures only
- D) None of the above are correct

How did you do on these fourteen questions? Remember, this is a Category 1 Chapter and the 1st section is the most important of all!

13 Risk Management with Inspection Activities

13.2 Identifying Risk Management Opportunities from RBI Results

As discussed in Section 12, typically a risk priority list is developed as a result of the RBI process. RBI will also identify whether consequence or POF or both is **driving risk**. In the situations where risk is being driven by POF, there is usually potential for **risk management through inspection**.

Once an RBI assessment has been completed, the items with higher or unacceptable risk should be assessed for potential risk management through inspection, or other risk management strategies.

Whether inspections will be effective or not will depend on:

- a) Equipment type
- b) Active and credible damage mechanism(s)
- c) Rate of deterioration or susceptibility
- d) Inspection methods, coverage and frequency
- e) Accessibility to expected damage areas
- f) Shutdown requirements

g) Amount of achievable reduction in POF (i.e. a reduction in POF of a low POF item is usually difficult to achieve through inspection)

Depending on factors such as the remaining life of the equipment and type of damage mechanism, **RISK MANAGEMENT THROUGH INSPECTION MAY HAVE LITTLE OR NO EFFECT.**

EXAMPLES OF SUCH CASES ARE:

- a) Corrosion rates well-established with equipment nearing end of life,
- b) Instantaneous failures related to operating conditions such as brittle fracture,
- c) Inspection technology that is not sufficient to detect or quantify deterioration adequately,
- d) Too short a time frame from the onset of deterioration to final failure for periodic inspections to be effective (e.g. high-cycle fatigue cracking),
- e) event-driven failures (circumstances that cannot be predicted),

In cases such as these, **an alternative form of mitigation may be required. The most practical and cost effective risk mitigation strategy can then be developed for each item.** Usually, inspection provides a major part of the overall risk management strategy, but not always.

13.2 ... Identifying Risk Mgmt Opportunities from RBI Results

15. In addition to a risk priority list that is developed as a result of the RBI process, RBI will also identify whether the consequence or POF or both is:

- A) Driving risk
- B) Increasing risk
- C) Decreasing risk
- D) Either increasing or decreasing risk

13.2 ... Identifying Risk Mgmt Opportunities from RBI Results

16. Regarding risk management, once an RBI assessment has been completed, the items with higher or unacceptable risk should be:

- A) Analyzed for potential risk management risk management strategies other than inspection
- B) Assessed for potential risk management thru Inspection or other risk management strategies
- C) Analyzed for potential risk management thru Inspection and other risk management strategies
- D) Assessed for potential risk management thru Inspection alone

17. Regarding risk management with Inspection, whether inspections will be effective or not will depend on all of the following EXCEPT:

- A) Equipment type and the active and credible damage mechanisms affecting the equipment
- B) The rate of deterioration or susceptibility, inspection methods, coverage and frequency
- C) Accessibility to expected damage areas, and the shutdown requirements
- D) Amount of achievable reduction in the COF

18. Regarding risk management with Inspection, which of these statements is true concerning a reduction in POF of a low POF item?

- A) A reduction in POF of a low POF item is not achievable through inspection

- B) A reduction in POF of a low POF item is usually easily achievable through inspection
- C) A reduction in POF of a low POF item is usually difficult to achieve through inspection
- D) A reduction in POF of a low POF item is extremely difficult to achieve through inspection

19. Depending on factors such as the remaining life of the equipment and type of damage mechanism, risk management through inspection may have:

- A) Little or no effect
- B) No effect at all
- C) Some effect, but not significant
- D) A significant effect

20. Examples of cases where risk management through inspection may have little or no effect includes all of the following EXCEPT:

- A) For equip nearing end of life with well-established corrosion rates & for event-driven failures
- B) Too short time frame (onset of damage to final failure) for periodic inspection to be effective
- C) For instantaneous failures related to operating conditions such as high-cycle fatigue cracking
- D) When Inspection technology is not sufficient to detect or quantify deterioration adequately

13 Risk Management with Inspection Activities

13.3 Establishing an Inspection Strategy Based on Risk Assessment

The results of an RBI assessment and the resultant risk management assessment are normally used as the basis for the development of **an overall inspection strategy for the group of items included.**

The inspection strategy should be designed in conjunction with other mitigation plans so that **all equipment items will have resultant risks that are acceptable.**

For the development of their inspection strategy, users should consider the following:

- Risk criteria and ranking
- Risk drivers
- Item history
- Number and results of inspections
- Type and effectiveness of inspections
- Equipment in similar service and remaining life

Inspection is only effective if the examination technique chosen is sufficient for detecting the damage mechanism and its severity. As an example, spot thickness readings on a piping circuit would be considered to have little or no benefit if the damage mechanism results in unpredictable localized corrosion (e.g. pitting, ammonia bisulfide corrosion, local thin area, etc.). In this case, ultrasonic scanning, radiography, etc. will be more effective.

LEVEL OF RISK REDUCTION ACHIEVED BY INSPECTION WILL DEPEND ON:

- a) Mode of failure of the damage mechanism
- b) Time interval between the onset of deterioration and failure (i.e. speed of deterioration)
- c) Detection capability of examination technique
- d) Scope of inspection

e) Frequency of inspection

Organizations should be **deliberate and systematic** in assigning the level of risk management achieved through inspection and should be cautious not to assume that there is an unending capacity for risk management through inspection.

The inspection strategy should be a **documented, iterative* (*repetitive) process to assure that inspection activities are continually focused on items with higher risk.**

21. When establishing an inspection strategy based on Risk Assessment, the results of an RBI assessment & resultant risk management assessment are normally used as the basis for the development of:

- A) A facility inspection and maintenance plan (such as that existing with PSM)
- B) A facility inspection and maintenance plan (such as that existing with PHA)
- C) An overall inspection strategy for the group of items included in the assessment
- D) An equipment inspection and non-inspection mitigation plan to reduce risk levels

22. Regarding inspection strategy based on risk assessment, inspection strategy should be designed in conjunction with other mitigation plans so that all equipment items will have:

- A) Resultant risks that are acceptable
- B) Mitigated risks that are acceptable
- C) Unmitigated risks that are acceptable
- D) None of these are correct

23. Regarding inspection strategy based on risk assessment, for the development of their inspection strategy, users should consider all of the following EXCEPT:

- A) Risk criteria and ranking, risk drivers, and the equipment item history
- B) Equipment in similar service and the equipment remaining life
- C) Number and results of the inspections performed
- D) Inspection intervals and detailed methods used

24. The level of risk reduction achieved by inspection will depend on all of these EXCEPT:

- A) Speed of deterioration
- B) Damage mechanism mode of failure
- C) Detection capability of the inspector
- D) Scope and frequency of inspection

25. Organizations should be cautious not to assume that there is an unending capacity for risk management through inspection, and should act (how) in assigning the level of risk management achieved through inspection?

- A) Cautiously and systematically
- B) Deliberately and systematically
- C) Cautiously and conservatively
- D) Conservatively and systematically

26. To assure that inspection activities are continually focused on items with higher risk, the inspection strategy (regarding Risk Assessment) should be what type of process?

- A) A documented & very efficient process B) A documented & repetitive process
- C) A documented & detailed process D) A documented & concise process

13 Risk Management with Inspection Activities

13.4 Managing Risk with Inspection Activities

The effectiveness of past inspections is part of the determination of the **present risk**. The future risk can now be influenced by future inspection activities. **RBI can be used as a “what if” tool to determine when, what and how inspections should be conducted to yield an acceptable future risk level.**

Key parameters & examples that can affect the future risk are as follows.

a) Frequency of Inspection—*Increasing the frequency of inspections may serve to better define, identify or monitor the damage mechanism(s) and therefore better quantify the risk. Both routine and turnaround inspection frequencies can be optimized.*

b) Coverage—*Different zones or areas of inspection of an item or series of items can be modeled and evaluated to determine the coverage that will produce an acceptable level of risk. For example:*

— A higher risk piping system may be a candidate for more extensive inspection, using one or more NDE techniques targeted to locating the identified damage mechanisms

— An assessment may reveal the need for focus on parts of a vessel where the highest risk may be located and focus on quantifying this risk rather than focusing on the rest of the vessel where there are perhaps only low risk deterioration processes occurring.

c) Tools and Techniques—*The selection and usage of the appropriate inspection tools and techniques can be optimized to cost effectively and safely quantify the POF.* In the selection of inspection tools and techniques, inspection personnel should take into consideration that more than one technology may achieve risk mitigation. *However, the level of mitigation achieved can vary depending on the choice. As an example, profile radiography would typically be more effective than digital ultrasonics for thickness monitoring in cases of localized corrosion.*

d) Procedures and Practices—*Inspection procedures and the actual inspection practices can impact the ability of inspection activities to identify, measure and/or monitor damage mechanisms. If the inspection activities are executed effectively by well-trained and qualified inspectors, the expected risk management benefits should be obtained. The user is cautioned not to assume that all inspectors and NDE examiners are well qualified and experienced, but rather to take steps to assure that they have the appropriate level of experience/qualifications.*

e) Internal, On-stream, or External Inspection—*Risk quantification by internal, on-stream and external inspections should be assessed.* Often external inspection with effective on-stream inspection techniques can provide useful data for risk assessment. **It is worth noting that invasive inspections, in some cases, may cause deterioration and increase the risk of the item.** Examples where this may happen include:

— **Moisture ingress to equipment leading to stress corrosion cracking or PTASCC**

- Internal inspection of glass lined vessels
- Removal of passivating films
- Human errors in startup (re-streaming)
- Increased risks associated with shutting down and starting up equipment

The user can adjust these parameters to obtain the optimum inspection plan that MANAGES RISK, IS COST EFFECTIVE, AND IS PRACTICAL.

13.4 ... Managing Risk with Inspection Activities

27. Regarding managing risk with inspection activities, RBI can be used as a “what if” tool to guide inspection as related to risk determination for all of the following EXCEPT:

- A) **How** inspections should be conducted to yield an acceptable future risk level
- B) **What** inspections should be conducted to yield an acceptable future risk level
- C) **When** inspections should be conducted to yield an acceptable future risk level
- D) **Where** inspections should be conducted to yield an acceptable future risk level

28. Regarding managing risk with inspection activities, key parameters that can affect the future risk include all of the following EXCEPT:

- A) Frequency of inspection
- B) Inspection limitations
- C) Inspection tools & techniques
- D) Inspection procedures and practices

29. Regarding managing risk with inspection activities, one of the key parameters that can affect the future risk is the Frequency of Inspection. Increasing the frequency of inspection may serve to better define, identify or monitor the damage mechanism(s) and therefore:

- A) Better quantify the risk
- B) Produce an acceptable level of risk
- C) Cost effectively & safely quantify POF
- D) Result in a risk reduction or elimination

30. Regarding managing risk with inspection activities, one of the key parameters that can affect the future risk is the Inspection Coverage. Different zones or areas of inspection of an item or series of items can be modeled & evaluated to determine the coverage that will:

- A) Better quantify the risk
- B) Produce an acceptable level of risk
- C) Cost effectively & safely quantify POF
- D) Result in a risk reduction or elimination

31. Regarding managing risk with inspection activities, one of the key parameters that can affect the future risk is Inspection Tools & Techniques. The selection and usage of the appropriate inspection tools and techniques can be optimized to:

- A) Better quantify the risk
- B) Produce an acceptable level of risk
- C) Cost effectively & safely quantify POF
- D) Result in a risk reduction or elimination

13.4 ... Managing Risk with Inspection Activities

32. Regarding managing risk with inspection activities, one of the key parameters that can affect the future risk is Inspection Procedures & Practices. Inspection procedures and the actual inspection practices can impact the ability of inspection activities to:

- A) Identify damage mechanisms
- B) Identify and measure damage mechanisms
- C) Identify, measure and/or monitor damage mechanisms
- D) None of the above are correct

33. Regarding managing risk with Insp activities, risk quantification by internal, on-stream and external inspections should be assessed because often external inspection with effective on-stream inspection techniques can:

- A) Better quantify the risk
- B) Produce an acceptable level of risk
- C) Cost effectively & safely quantify POF
- D) Provide useful data for risk assessment

34. Regarding managing risk with inspection activities, it is worth noting that invasive inspections, in some cases, may cause deterioration and increase the risk of the item. Examples where this may happen include all of the following EXCEPT:

- A) Moisture ingress to equip leading to stress corrosion cracking or polythionic acid cracking
- B) Internal inspection of fragile (easily broken/cracked) glass lined pressure vessels
- C) Increased risks associated with operating equipment at elevated temps
- D) Removal of passivating (protecting) films during cleaning

35. Regarding managing risk with inspection activities, the five key parameters (Inspection frequency, coverage, tools & techniques, procedures & practices, Internal/On-Stream/Ext) can be adjusted by the API 580 user to obtain the OPTIMUM INSPECTION PLAN that:

- A) Manages risk, is cost effective, and is practical
- B) Achieves lowest life cycle costs and is practical
- C) Reduces risk and is cost effective and is practical
- D) None of the above is correct

13 Risk Management with Inspection Activities

13.5 Managing Inspection Costs with RBI

Inspection costs can be more effectively managed through the utilization of RBI.

Resources can be applied or shifted to those areas identified as a higher risk or targeted based on the strategy selected. Consequently, this same strategy allows consideration for reduction of inspection activities in those areas that have a lower risk or where the inspection activity has

little or no effect on the associated risks. This results in inspection resources being applied where they are needed most and thereby increased inspection cost effectiveness.

Another opportunity for managing inspection costs is by identifying items in the inspection plan that can be **inspected non-intrusively on-stream**. If the non-intrusive inspection provides sufficient risk management, there is a potential for a net savings based on not having to blind, open, clean, and internally inspect during downtime.

If the item considered is the main driver for bringing an operational unit down, the non-intrusive inspection may contribute to **increased uptime of the unit**.

The user should recognize that while there is a potential for the reduction of inspection costs through the utilization of RBI, increased equipment integrity and inspection cost optimization should remain the focus.

13.5 ... Managing Inspection Costs with RBI

36. Regarding managing risk with inspection, Inspection costs can be more effectively managed through the utilization of:

- A) RBI
- B) Proper inspection tools & techniques
- C) Well-trained/qualified/experienced inspectors
- D) Effective inspection procedures

37. Regarding managing risk with inspection, which of the following inspection actions does not result in increased inspection cost effectiveness?

- A) Insp resources can be reduced in areas where Insp has little or no effect on associated risks
- B) Resources can be applied or shifted to those areas targeted based on the strategy selected
- C) Resources can be applied or shifted to those areas identified as having risks
- D) Inspection resources can be applied wherever they are most needed

38. An opportunity for managing inspection costs is by identifying items in the inspection plan that can be inspected:

- A) During Turnarounds
- B) During planned Unit Shut Downs
- C) During unplanned Unit Shut Downs
- D) Non-intrusively on-stream

13.5 ... Managing Inspection Costs with RBI

39. Regarding managing risk with inspection, if the item considered is the main driver for bringing an operational unit down, the non-intrusive inspection may contribute to:

- A) Significant risk reduction
- B) Increased uptime of the unit
- C) Significant cost savings based on inspection
- D) None of the above is correct

40. The API 580 user should recognize that while there is a potential for the reduction of inspection costs through the utilization of RBI, the focus should remain on:

- A) Inspection cost optimization
- B) Increased equipment integrity
- C) Decreased equipment risk associated with inspection costs
- D) Increased equipment integrity and inspection cost optimization

13.6 Assessing Inspection Results & Determining Corrective Action

Inspection results such as the identification of damage mechanisms, rate of deterioration and equipment tolerance to the types of deterioration should be used as variables in assessing REMAINING LIFE AND FUTURE INSPECTION PLANS.

Inspection results can also be used for comparison or validation of the models that may have been used for POF determination.

A DOCUMENTED MITIGATION ACTION PLAN should be developed for any equipment item requiring repair or replacement.

The (documented mitigation) action plan should describe the **EXTENT OF REPAIR (OR REPLACEMENT), RECOMMENDATIONS, THE PROPOSED REPAIR METHOD(S), APPROPRIATE QA/QC AND THE DATE THE PLAN SHOULD BE COMPLETED.**

No questions expected

13.7 Achieving Lowest Life Cycle Costs with RBI

Not only can RBI be used to **optimize inspection costs** that directly affect life cycle costs, it can assist in **lowering overall life cycle costs thru VARIOUS COST BENEFIT ASSESSMENTS.**

The following examples can give user ideas on how to lower life cycle costs through RBI with cost benefit assessments.

a) RBI should enhance the prediction of failures caused by damage mechanisms. *This in turn should give the user confidence to continue to operate equipment safely, closer to the predicted failure date. By doing this, equipment cycle time should increase and life cycle costs decrease.*

b) RBI can be used to assess the effects of changing to a more aggressive fluid. *A subsequent plan to upgrade construction material or replace specific items can then be developed. The*

construction material plan would consider the optimized run length safely attainable along with the appropriate inspection plan. This could equate to increased profits and lower life cycle costs through reduced maintenance, optimized inspections, and increased unit/equipment uptime.

c) Turnaround and maintenance costs also have an effect on the life cycle costs of an equipment item. By using the results of the RBI inspection plan to identify more accurately where to inspect and what repairs and replacements to expect, turnaround and maintenance work can be preplanned and, in most cases, executed at a lower cost than if unplanned.

Examples include all of the following except ...

No questions expected

End section 13

Expect 8 – 10 Qs

How did you do on the 40?

Expect 3 Qs each in Sect. 14 – 17

14 Other Risk Mitigation Activities

14.1 General

As described in the previous section, inspection is often an effective method of risk management. *However, inspection may not always provide sufficient risk mitigation or may not be the most cost effective method. The purpose of this section is to describe other methods of risk mitigation. This list is not meant to be all inclusive.*

THESE RISK MITIGATION ACTIVITIES FALL INTO ONE OR MORE OF THE FOLLOWING:

- a) Reduce the magnitude of consequence
- b) Reduce the POF

- c) Enhance the survivability of the facility and people to the consequence
- d) Mitigate the primary source of consequence

14.2 Equipment Replacement and Repair

When equipment deterioration has reached a point that the risk of failure cannot be managed to an acceptable level, REPLACEMENT/REPAIR is often the only way to mitigate the risk.

14.3 Evaluating Flaws for Fitness-For-Service

Inspection may identify flaws in equipment.

A FITNESS-FOR-SERVICE ASSESSMENT (E.G. API 579-1/ASME FFS-1) may be performed to determine if the equipment may continue to be safely operated, under what conditions and for what time period.

A FITNESS-FOR-SERVICE ANALYSIS can also be performed to determine what size flaws, if found in future inspections, would require repair or equipment replacement.

14.4 Equipment Modification, Redesign, and Rerating

Modification and redesign of equipment, UTILIZING A RIGOROUS MOC PROCESS, can provide mitigation of POF.

Examples include:

- a) Change of metallurgy,
- b) Addition of protective linings and coatings,
- c) Removal of deadlegs,
- d) Increased corrosion allowance,
- e) Physical changes that will help to control/minimize deterioration,
- f) Insulation improvements,
- g) Injection point design changes,
- h) Resizing of the relief device.

Sometimes equipment is over designed for the process conditions.

RERATING the equipment may result in a reduction of the POF assessed for that item.

14 Other Risk Mitigation Activities

14.5 Emergency Isolation

Emergency isolation capability can reduce toxic, explosion or fire consequences in the event of a release. Proper location of the isolation valves is key to successful risk mitigation.

REMOTE OPERATION is usually required to provide significant risk reduction.

To mitigate flammable and explosion risk, operations need to be able to detect the release and actuate the isolation valves quickly (within a few minutes).

Longer response times may still mitigate effects of ongoing fires or toxic releases.

14.6 Emergency Depressurizing/Deinventorying

This method reduces the amount and rate of release. Like emergency isolation, the emergency depressurizing and/or deinventory should be achieved **within a few minutes to affect explosion/fire risk.**

14.7 Modify Process

Mitigation of the primary source of consequence may be achieved by changing the process towards less hazardous conditions. As with physical modifications, any process changes should be conducted only after the application of a **RIGOROUS MOC PROCESS.** Examples include:

- a) Reduce temperature to below atmospheric pressure boiling point to reduce size of cloud;
- b) Substitute a less hazardous material (e.g. high flash solvent for a low flash solvent);
- c) Use a continuous process instead of a batch operation, where applicable;
- d) Dilute or eliminate hazardous substances.

Mitigation of the sources of corrosion can be achieved by changing the process towards less corrosive conditions.

Some examples include:

- a) Process water washing to remove corrosive materials (e.g. salts);
- b) Addition of neutralizing or inhibitor chemicals;
- c) Removal of contaminants with process equipment (e.g. absorbers, filters);
- d) Protection of downtime corrosion (e.g. PTASCC protection).

14.8 Establish IOWs

IOWs should be established for process parameters (both physical and chemical) that could impact equipment integrity if not properly controlled. Examples of the process parameters include temperatures, pressures, fluid velocities, pH, flow rates, chemical or water injection rates, levels of corrosive constituents, chemical composition, etc.

Key process parameters for IOWs should be identified and implemented, upper and lower limits established, as needed, and deviations from these limits should be **BROUGHT TO THE ATTENTION OF INSPECTION/ENGINEERING PERSONNEL.**

Particular attention to monitoring IOWs should also be provided during ...

START-UPS, SHUTDOWNS & SIGNIFICANT PROCESS UPSETS → must know!!!

14 Other Risk Mitigation Activities

14.9 Reduce Inventory

This method reduces the **magnitude of consequence.** Some examples include:

- a) Reduce/eliminate storage of hazardous feedstocks or intermediate products
- b) Modify process control to permit a reduction in inventory contained in surge drums, reflux drums or other in-process inventories

c) Modify process operations to require less inventory/hold-up

d) Substitute gas phase technology for liquid phase

14.10 Water Spray/Deluge

This method can reduce fire damage and minimize or prevent escalation. A properly designed / operating system can greatly reduce the probability that a vessel exposed to fire will **BLEVE**.

14.11 Water Curtain

Water sprays entrap large amounts of air into a cloud.

Water curtains mitigate water soluble vapor clouds by absorption as well as dilution and insoluble vapors (including most flammables) by air dilution.

Early activation is required in order to achieve significant risk reduction. The curtain should preferably be between the release location and ignition sources (e.g. furnaces) or locations where people are likely to be present. Design is critical for flammables, since the water curtain can enhance flame speed under some circumstances.

14.12 Blast-resistant Construction

Utilizing blast resistant construction provides mitigation of the damage caused by explosions and may prevent escalation of the incident. When used for buildings (see API 752), it may provide personnel protection from the effects of an explosion. This may also be useful for equipment critical to emergency response, critical instrument/control lines, etc.

14.13 Others

- a) Spill detector, b) Steam or air curtains, c) Fireproofing,
- d) Instrumentation (interlocks, shutdown systems, alarms, etc.),
- e) Inerting/gas blanketing, f) Ventilation of buildings and enclosed structures,
- g) Piping redesign, h) Mechanical flow restriction, i) Ignition source control
- j) Improved design, assembly and installation standards, k) Improvement in PSM program,
- l) Emergency evacuation, m) Shelters (safe havens), n) Toxic scrubbers on building vents
- o) Spill detectors and containment, p) Facility siting and/or layout, q) Condition monitoring
- r) Improved training/procedures, s) Emergency feed stops, t) Improved fire suppression systems

15 Reassessment and Updating RBI Assessments

15.1 RBI Reassessments

RBI is a dynamic tool that can provide current and projected future risk evaluations.

However, these evaluations are based on data and knowledge at the time of the assessment.

As time goes by, changes are inevitable and the results from the RBI assessment should be updated.

It is important to maintain and update an RBI program to ensure that the most recent inspection, process, and maintenance information is included.

The results of inspections, changes in process conditions and implementation of maintenance practices can all have significant effects on risks, and therefore the inspection plan and can trigger the need to perform a reassessment.

15.2 Why Conduct an RBI Reassessment?

15.2.1 General

There are several events that will change risks and make it prudent to conduct an RBI reassessment.

It is important that the facility have an effective MOC process that identifies when a reassessment is necessary.

Sections 15.2.2 through 15.2.5 provide guidance on some key factors that could trigger an RBI reassessment.

15.2.2 Damage Mechanisms and Inspection Activities

Many damage mechanisms are time dependent. Typically, the RBI assessment will project deterioration at a continuous rate. In reality, the deterioration rate may vary over time.

Through inspection activities, the rate of deterioration (both short-term and long-term) may be better defined.

Some damage mechanisms are independent of time (i.e. they occur only when there are specific conditions present).

When those intermittent conditions occur, then an RBI reassessment may be appropriate.

As part of the reassessments, it is important to review the operating histories over the past run, including exceedances and trends, to better predict if non-time dependent damage mechanisms could have occurred.

Inspection activities will increase information on the condition of the equipment.

When inspection activities have been performed, the results should be reviewed to determine if an RBI reassessment is necessary.

15 Reassessment and Updating RBI Assessments

15.2 Why Conduct an RBI Reassessment?

15.2.3 Process and Hardware Changes

Changes in process conditions and hardware, such as equipment modifications or replacement, frequently can significantly alter the risks, and dictate the need for a reassessment.

Process changes, in particular, have been linked to equipment failure from rapid or unexpected corrosion or cracking.

This is particularly important for damage mechanisms that depend heavily on process conditions.

Typical examples include chloride stress corrosion cracking of stainless steel, wet H₂S cracking of carbon steel, and accelerated corrosion at points of salt deposition or at dew points and sour water corrosion. In each case, a change in process conditions can dramatically affect the corrosion rate or cracking tendencies. Hardware changes can also have an effect on risk. For example:

- a) POF can be affected by changes in the design of internals in a vessel or size and shape of piping systems that accelerate velocity related corrosion effects;
- b) COF can be affected by the relocation of a vessel to an area near an ignition source;
- c) Process conditions can be changed by hardware modifications, additions, deletions, or by-passing.

15.2.4 RBI Assessment Premise Change

The premises for the RBI assessment could change and have a significant impact on the risk results. Some of the possible changes could be:

- a) Increase or decrease in population density in the process unit,
- b) Change in construction material and repair/replacement costs,
- c) Change in product values,
- d) Revisions in safety and environmental laws and regulations,
- e) Revisions in the users risk management plan (such as changes in risk criteria),
- f) Change in feed amount or composition,
- g) Changes in operating conditions,
- h) Change in unit operating lengths between maintenance turnarounds.

15.2.5 The Effect of Mitigation Strategies

Strategies to mitigate risks such as installation of safety systems, repairs etc. should be monitored to ensure that they have successfully achieved the desired mitigation.

Once a mitigation strategy is implemented, a reassessment of the risk may be performed to update the RBI program with the new current risks.

15 Reassessment and Updating RBI Assessments

15.3 When to Conduct an RBI Reassessment

15.3.1 After Significant Changes

As discussed in 15.2, significant changes in risk can occur for a variety of reasons.

Qualified personnel should evaluate each significant change to determine the potential for a change in risk.

It may be desirable to conduct an RBI reassessment after significant changes in process conditions, damage mechanisms/rates/severities or RBI premises.

15.3.2 After a Set Time Period

Although significant changes may not have occurred, over time many small changes may occur and cumulatively cause significant changes in the RBI assessment.

Users should set default maximum time periods for reassessments.

The governing inspection codes (such as API 510, API 570, and API 653) and jurisdictional regulations, if any, should be reviewed in this context.

15.3.3 After Implementation of Risk Mitigation Strategies

Once a mitigation strategy is implemented, it is prudent to determine how effective the strategy was in reducing the risk to an acceptable level.

This should be reflected in a reassessment of the risk & appropriate update in the documentation.

15.3.4 Before and After Maintenance Turnarounds

As part of the planning for a maintenance turnaround, it is usually useful to perform an RBI reassessment.

This can become a first step in planning the turnaround to ensure that the work effort is focused on the higher risk equipment items and on issues that might affect the ability to achieve the premised operating run time in a safe, economic, and environmentally sound manner.

Since a large number of inspection, repairs, and modifications are performed during a typical maintenance turnaround, it may be useful to update an assessment soon after the turnaround to reflect the new risk levels.

16 Roles, Responsibilities, Training, and Qualifications

16.1 Team Approach

RBI requires data gathering from many sources, specialized analysis, such as risk analysis, financial analysis, materials and corrosion engineering, mechanical engineering, inspection, etc. followed by risk management decision-making.

Generally, one individual does not have the background or skills to single-handedly conduct the entire study effectively.

Usually, a team of people, with the requisite skills and background, is needed to conduct an effective RBI assessment.

RBI analyses should be conducted as a project with plant management as stakeholders and a project team composed of the types of members depicted in 16.2.2 through 16.2.10.

16.2 Team Members, Roles, and Responsibilities

16.2.1 General

Depending on the application, some of the disciplines listed below may not be required. Some team members may be part-time due to limited input needs. It is also possible that not all the team members listed may be required if other team members have the required skill and knowledge of multiple disciplines. It is usually useful to have one of the team members serve as a facilitator for discussion sessions and team interactions.

16.2.2 Team Leader

The team leader may be any one of the below mentioned team members. The team leader should be a full-time team member, and should preferably be a stakeholder in the facility/equipment being analyzed. In cases where the team leader is unfamiliar with the facility to be evaluated, he or she should be familiar with the RBI methodology employed and the types of processes to be assessed. The team leader may be knowledgeable in one of the specialized fields required for RBI. **The main function of the team leader should be to integrate the inputs, outputs, organizational structure, communications, etc. of the assessment team and to carry out the following responsibilities:**

- a) Formation of the team and verifying that the team members have the necessary skills, experience and knowledge;
- b) Assuring that the study is conducted properly:
 - Data gathered is accurate,
 - Assumptions made are logical and documented,
 - Appropriate personnel are utilized to provide data and assumptions,
 - Appropriate quality & validity checks are employed on data gathered and on data analysis;
- c) Preparing a report on the RBI assessment and distributing it to the appropriate stakeholders whom are either responsible for decisions on managing risks or responsible for implementing actions to mitigate the risks;
- d) Following up to assure that the appropriate risk mitigation actions have been implemented.

16 Roles, Responsibilities, Training, and Qualifications

16.2 Team Members, Roles, and Responsibilities

16.2.3 Equipment Inspector or Inspection Specialist

The equipment inspector or inspection specialist is generally responsible for gathering data on the condition and history of equipment in the study. This condition data should include the new/design condition and current condition.

Generally, this information will be located in equipment inspection and maintenance files. If condition data are unavailable, the inspector/specialist, in conjunction with the corrosion specialist, should provide predictions of the current condition.

The inspector/specialist and materials and corrosion specialist are also responsible for assessing the effectiveness of past inspections.

The equipment inspector/inspection specialist is usually responsible for implementing the recommended inspection plan derived from the RBI assessment.

16.2.4 Corrosion Specialist

The corrosion specialist is responsible for assessing the types of damage mechanisms and their applicability and severity to the equipment considering the process conditions, environment, metallurgy, age, etc., of the equipment.

This specialist should compare this assessment to the actual condition of the equipment, determine the reason for differences between predicted and actual condition, and provide guidance on damage mechanisms, rates or severity to be used in the RBI assessment.

Part of this comparison should include evaluating the appropriateness of the inspections in relation to the damage mechanism.

This specialist also should provide recommendations on methods of mitigating the POF (such as changes in metallurgy, addition of inhibition, addition of coatings/linings, etc.) and methods of monitoring the process for possible changes in damage rates (such as pH monitoring, corrosion rate monitoring, contaminant monitoring, etc.).

16.2.5 Process Specialist

The process specialist is responsible for the provision of process condition information.

This information generally will be in the form of process flow sheets.

The process specialist is responsible for documenting variations in the process conditions due to normal occurrences (such as start-ups and shutdowns) and abnormal occurrences.

The process specialist is responsible for describing the composition and variability of all the process fluids/gases as well as their potential toxicity and flammability.

The process specialist should evaluate/recommend methods of risk mitigation (probability or consequence) through changes in process conditions.

16 Roles, Responsibilities, Training, and Qualifications

16.2 Team Members, Roles, and Responsibilities

16.2.6 Operations and Maintenance Personnel

Operations personnel are responsible for verifying that the facility/equipment is being operated within the parameters set out in the process operating window.

They are responsible for providing data on occurrences when process deviated from the limits of the operating windows, and on any trends in the operating data over the past unit run, including IOW parameters.

They are also responsible for verifying that equipment repairs/replacements/additions have been included in the equipment condition data supplied by the equipment inspector.

Operations and maintenance are responsible for implementing recommendations that pertain to process or equipment modifications and monitoring.

16.2.7 Management

Management's role is provide sponsorship/resources (personnel, funds) for RBI assessment.

They are responsible for making decisions on risk management, establishing risk acceptance criteria and/or providing the framework/mechanism for others to make these decisions based on the results of the RBI assessment.

Finally, management is responsible for providing the resources and follow-up system to implement the risk mitigation decisions.

16.2.8 Risk Analyst

This person(s) is responsible for assembling all of the data and carrying out the RBI analysis.

This person(s) could be a separate specialist or one of the above team members and is typically responsible for:

- a) Defining data required from other team members,
- b) Defining accuracy levels for the data,
- c) Verifying through quality checks the soundness of data and assumptions,
- d) Inputting/transferring data into a computer program and running the program (if one is used),
- e) Quality control of data input/output,
- f) Manually calculating the measures of risk (if a computer program is not used),
- g) Displaying results in an understandable way & preparing appropriate reports on RBI analysis.

Furthermore, this person(s) should be a resource to the team conducting a cost/benefit analysis if it is deemed necessary.

16 Roles, Responsibilities, Training, and Qualifications

16.2 Team Members, Roles, and Responsibilities

16.2.9 Environmental and Safety Personnel

This person(s) is responsible for providing data on environmental and safety systems and regulations.

He/she also is responsible for assessing/recommending ways to mitigate the COFs.

16.2.10 Financial/Business Personnel

This person(s) is responsible for providing data on the cost of the facility/equipment being analyzed and the financial impact of having pieces of equipment or the facility shut down.

He/she also should recommend methods for mitigating the financial COF.

16.3 Training and Qualifications for RBI Application

16.3.1 Risk Assessment Personnel

This person(s) should have a thorough understanding of risk analysis by education, training, and/or experience.

He/she should have received detailed training on the RBI methodology and on the procedures being used for the RBI assessment so that he/she understands how the program operates and the vital issues that affect the final results.

Contractors that provide risk assessment personnel for conducting RBI analysis should have a program of training and be able to document that their personnel are suitably qualified and experienced.

Facility owners that have internal risk assessment personnel to conduct RBI analysis should have a procedure to document that their personnel are sufficiently qualified.

The qualifications and training of the risk assessment personnel should be documented.

16.3.2 Other Team Members

The other team members should receive basic training on RBI methodology and on the software program(s) being used, to the extent they need to understand software to make their contribution.

This training should be geared primarily to an understanding and effective application of RBI, as well as an understanding of how the data quality that is input by other team members can affect the results.

This training could be provided by the risk assessment personnel on the RBI Team or by another person knowledgeable on RBI methodology and on the program(s) being used.

17 RBI Documentation and Recordkeeping

17.1 General

It is important that sufficient information is captured to fully document the RBI assessment. Typically, this documentation should include the following data & info:

- a) The type of assessment, objectives, and boundaries;
- b) A procedure for how the selected RBI methodology will be applied at the site (e.g. how to deal with all the options provided by the methodology);
- c) Team members performing the assessment and their skill set relative to RBI;
- d) Time frame over which the assessment is applicable;
- e) The inputs and sources used to determine risk;
- f) Assumptions made during the assessment;
- g) The risk assessment results (including information on probability and consequence);
- h) Follow-up mitigation strategy, if applicable, to manage risk;
- i) The mitigated risk levels (i.e. residual risk after mitigation is implemented);
- j) References to in-service codes or standards being applied.

Ideally, sufficient data should be captured and maintained such that the assessment can be recreated or updated at a later time by others who were not involved in the original assessment.

To facilitate this, it is preferable to store the information in a computerized database.

This will enhance the analysis, retrieval, and stewardship capabilities.

The usefulness of the database will be particularly important in stewarding recommendations developed from the RBI assessment, and managing overall risk over the specified time frame.

17.2 RBI Methodology

The methodology used to perform the RBI analysis should be documented so that it is clear what type of assessment was performed.

The basis for both the probability and consequences of failure should be documented.

If a specific software program is used to perform the assessment, this also should be documented.

The documentation should be sufficiently complete so that the basis and the logic for the decision making process can be checked or replicated at a later time.

17 RBI Documentation and Recordkeeping

17.3 RBI Personnel

The assessment of risk will depend on the knowledge, experience and judgment of the personnel or team performing the analysis.

Therefore, a record of the team members involved should be captured, as well as the skill set that they bring to the team for RBI purposes.

This will be helpful in understanding the basis for the risk assessment when the analysis is repeated or updated.

17.4 Time Frame

The level of risk is usually a function of time.

This either is as a result of the time dependence of a damage mechanism, or simply the potential for changes in the operation of equipment.

Therefore, the time frame over which the RBI analysis is applicable should be defined and captured in the final documentation.

This will permit tracking and management of risk effectively over time.

17.5 Basis for the Assignment of Risk

The various inputs used to assess both the probability and COF should be captured.

This should include, but not necessarily be limited to, the following information:

- a) Basic equipment data and inspection history critical to the assessment (e.g. operating conditions, materials of construction, service exposure, corrosion rate, inspection history, etc.);
- b) Operative and credible damage mechanisms;
- c) Criteria used to judge the severity of each damage mechanism;
- d) Anticipated failure mode(s) (e.g. leak, crack, or rupture);
- e) Key factors used to judge the severity of each failure mode;
- f) Criteria used to evaluate the various consequence categories, including safety, health, environmental and financial;
- g) Risk criteria used to evaluate the acceptability of the risks.

17 RBI Documentation and Recordkeeping

17.6 Assumptions Made to Assess Risk

Risk analysis, by its very nature, requires that certain assumptions be made regarding the nature and extent of equipment deterioration.

Moreover, the assignment of failure mode and the severity of the contemplated event will invariably be based on a variety of assumptions, regardless of whether the analysis is quantitative or qualitative.

To understand the basis for the overall risk, it is essential that these factors be captured in the final documentation.

Clearly documenting the key assumptions made during the analysis of probability and consequence will greatly enhance the capability to either recreate or update the RBI assessment.

17.7 Risk Assessment Results

The probability, consequence and risk results should be captured in the documentation.

For items that require risk mitigation, the recommendations for and results after mitigation should be documented as well.

17.8 Mitigation and Follow-up

One of the most important aspects of managing risk through RBI is the development and use of mitigation strategies.

Therefore, the specific risk mitigation required to reduce either probability or consequence should be documented in the assessment.

The mitigation “credit” assigned to a particular action should be captured along with any time dependence.

The methodology, process and person(s) responsible for implementation of any mitigation should also be documented.

17.9 Applicable Codes, Standards & Government Regulations

Since various codes, standards and governmental regulations cover the inspection for most pressure equipment, it will be important to reference these documents as part of the RBI assessment.

This is particularly important where implementation of RBI is used to reduce either the extent or frequency of inspection.

See Section 3 for a listing of some relevant codes and standards.

18 Summary of Risk-Based Inspection Pitfalls

18.1 General

The following is a bulletized summary list of potential pitfalls covered in previous sections of this RP that could lead to less than adequate risk management results from using RBI.

It can be used as checklist to review the RBI work process or to audit the effectiveness of an RBI program.

**Chapter 18 is NOT on
API 580 exams**