

# Risk-Based Inspection Methodology

## Part 2—Probability of Failure Methodology

### Annex 2.A—Management Systems Workbook

#### 2.A.1 Recommended Auditing Technique

The management systems evaluation covers a wide range of topics and, as a result, requires input from several different disciplines within the facility to answer all questions. Ideally, representatives from the following plant functions should be interviewed:

- a) Plant Management
- b) Operations
- c) Maintenance
- d) Safety
- e) Inspection
- f) Training
- g) Engineering

The number of separate interviews required to complete the management systems evaluation will vary from application to application. In many cases, one individual can effectively answer the questions concerning two or more of the above functions. Normally at least four interviews are required.

The number of auditors involved is arbitrary, but there is some advantage in using more than one. With two or more auditors, the management systems evaluation team can compare notes and often avoid overlooking or misinterpreting important information.

The people to be interviewed should be designated, and then a subset of questions should be selected from the total management systems evaluation, to match the expertise of each person being interviewed. All audit questions should be answered, and there should be no hesitation to include some of the audit questions in more than one interview. This is sometimes important to provide continuity and clarity during the interview. In addition, it can be revealing to compare answers from different disciplines as peoples' perceptions can differ markedly.

The intent of the management systems evaluation is to arrive at the single best answer for each question. In addition to comparing answers from different interviews, many of the responses should be verified by physical review of the appropriate written procedures, files and records. The auditor must ensure that the facts substantiate the answer, and that the intent of the question is met before credit is awarded for the answer.

#### 2.A.2 Example Workbook Scoring Instructions

The Management System evaluation/audit should be conducted per the guidance outlined in [Section 2.A.1](#). The team should review each question and develop a score by consensus. The team members should be set up for each section to include the appropriate subject matter experts and stake holders.

The following guidance should be used in assigning points to each question:

- a) Where scoring guidance is supplied with the question, that guidance should be applied
- b) Where the question is a simple yes/no either the full points should be awarded or no points as appropriate.
- c) For question which are related to more broad requirements, and larger point values are assigned, partial credit may be assigned based on how *well* the site meets the requirement.
- d) If a question does not apply because it relates to something that is not physically at the site, or is outside the scope of the RBI program, full points should be awarded. An example would be questions related to cathodic protection where a site has no underground equipment or atmospheric tanks with floors in contact with the earth where cathodic protection provides benefit, or if such equipment is outside the

scope of the RBI program and is covered by time-based inspections.

The total points for each section should be added up after the scoring for each question is complete. This score provides a rating of how well the site is doing on a scale of 1 to 100 for that section, showing the site's strengths and weaknesses in their Management systems. The section scores are then multiplied by the weighting as shown in Table 3.3 and totaled to provide a final management system evaluation, *p*score, from 1 to 100.

**Table 2.A.1 – Site Management**

Item	Question	Possible Score	Actual Score	Score Guidance
1	Does Site Management receive KPI's from the inspection group periodically regarding overdue inspection and recommendations?	15		
2	Is site management required to review and approve deferrals for MI program Inspections and Recommendations, prior to them becoming overdue, and receives sufficient technical information to understand the risk associated with those deferrals?	10		5 pts for having written requirement + 5 pts for following requirement (no over dues without deferral) + 3 pts for completeness of technical information provided to mgmt on risk associated with deferral
3	Is the site management aware of the requirements of a successful RBI program such as training, MOC involvement and periodic RBI reassessments and do they support providing adequate resources for these activities?	25		0 -25 based on interview with leadership staff
4	Does Site management approve and provide resources for the annual plan for the inspections to maintain equipment at an acceptable risk?	15		5 pts for having an annual plan +5 for approval +5 for evidence plan is sufficient to meet inspection requirements
6	Do other departments (for example, operations, maintenance and capital project group) communicate with RBI assessment group for anything that could change equipment risks such as equipment and piping replacements, modifications, or changes in operations?	10		
7	The site conducts periodic internal assessments:			
	PSM Based assessment or other overall plant bench marking, which includes FEMI programs	5		5 points for every 3 years or more frequent, 2 points for having done it at all
	FEMI Program specific assessment vs site and company requirements <b>OR</b> external assessment such as from API utilizing 3rd party subject matter experts.	10		10 pts for annual, 8 pts for at least every 3 yrs, 3 pts for in last 10 yrs.
8	Is there evidence of the site continuously improving their practices in accordance with industry best practices?	10		0 - 10 pts depending on strength of examples
	<b>Total for Section</b>	<b>100</b>	<b>0</b>	

**Table 2.A.2 – Process Safety**

Item	Question	Possible Score	Actual Score	Score Guidance
1	Is a block flow diagram or simplified process flow diagram available to aid in the understanding of the process?	10		0 -10 pts based on percentage of PFD's available for RBI units
2	Are as-built / up to date P&IDs available for all units at the site (in the RBI program)?	30		0 -30 pts based on the percentage of P&ID's that are currently up to date.
3	Does documentation show all equipment and piping in the unit (in the RBI program) is designed and constructed in compliance with all applicable codes, standards, and generally accepted good engineering practices?	20		0 pts if the documentation is lacking or if the site does not have equipment/piping designed and fabricated to recognized standards 10 pts if some documentation is found missing 20 pts if documentation is complete and requirements are robust.
4	IOW limits are established per API RP 584 with clear corrective action, communication and inspection follow-up requirements	40		15 pts for establishing IOW's +13 pts for having corrective actions documented +12 pts for having communication plan with inspection
	<b>Total for Section</b>	<b>100</b>	<b>0</b>	

**Table 2.A.3 – Management of Change**

Item	Question	Possible Score	Actual Score	Score Guidance
1	a. Does the facility have a written Management of Change procedure that must be followed whenever new facilities are added or changes are made to a process?	3		
	b. Does the MOC process include MI reviewing the change during various stages of the project before the actual installation is complete? I.E. Concept, Design, Issue for Construction, and As-Built.	3		
	c. Are authorization procedures clearly stated, approved by an appropriate discipline, and at an appropriate level?	3		
	d. Is there a requirement in the procedure to update RBI information and inspection plans with the changes?	10		
2	Do the following types of "changes" invoke the Management of Change procedure?			
	a. Physical changes to the facility, other than replacement in kind (expansions, equipment modifications, instrument or alarm system revisions (that are part of an IOW program), etc.).	3		
	b. Changes in process chemicals (feedstocks, catalysts, solvents, etc.).	3		
	c. Changes in process conditions (operating temperatures, pressures, production rates, etc.).	3		

Item	Question	Possible Score	Actual Score	Score Guidance
	d. Significant changes in operating procedures (startup or shutdown sequences, unit staffing level or assignments, etc.).	2		
3	a. Is there a clear definition of what constitutes a "temporary changes"?	3		
	b. Does Management of Change handle temporary changes as well as permanent changes?	2		
	c. Are items that are installed as "temporary" tracked to ensure that they are either removed after a defined period of time or reclassified as permanent?	3		
	d. Are items that are installed as "temporary" have an inspection plan implemented until the permanent repair as been installed or document justification for no inspection require for the life of the repair?	3		
4	Do the Management of Change procedures specifically require the following actions whenever a change is made to a process?			
	a. Update all affected maintenance programs, corrosion management programs (e.g. CCD, Damage mechanism reviews), inspection plans, and inspection schedules.	2		
	b. Modify P&IDs, statement of operating limits, Safety Data Sheets, and any other process safety information affected.	2		
	c. Notify all impacted FEMI and maintenance employees who work in the area of the change, and provide training as required .	2		
	d. Review the effect of the proposed change on all separate but interrelated upstream and downstream facilities.	2		
5	When changes are made in the process or operating procedures, are there written procedures requiring that the impact of these changes on the equipment and materials of construction be reviewed to determine whether they will cause any increased rate of damage or failure, or will result in different failure mechanisms in the process equipment?	5		
6	When the equipment or materials of construction are changed through replacement or maintenance items, is there a system in place to formally review any metallurgical change to ensure that the new material is suitable for the process?	10		
7	Is the MOC program audited periodically to ensure the MOC procedures are being followed and to verify all past MOC updates (including RBI information) are being completed in a timely manner.	10		
9	Is there a robust system to ensure an MOC's cannot be closed out without verification that equipment documentation, inspection plans, RBI information is completely updated.	20		
10	Is there an MOC process for changes in personnel or organizations? This could be when you add, reduce replace personnel.	4		

Item	Question	Possible Score	Actual Score	Score Guidance
11	Are in-kind replacements appropriately communicated to the FEMI team? I..E. Pressure Vessels are typically never true in-kind replacements. Materials of construction, year/version of design code, U1 form. Calculations, fabrication drawings will all be different.	2		
	<b>Total for Section</b>	<b>100</b>	<b>0</b>	

**Table 2.A.4 – Operating Procedures**

Item	Question	Possible Score	Actual Score	Score Guidance
1	Are written operating procedures available to operations, maintenance and SME personnel in all units?	10		
2	Do the operating procedures clearly define the position of the person or persons responsible for operation of each applicable area?	10		
3	Are the following operating considerations covered in all Standard Operating Procedures (SOPs)?			
	a. Initial startup	4		
	b. Normal (as well as emergency) operation	4		
	c. Normal shutdown	4		
	d. Emergency shutdown	4		
	e. Is the position of the person or persons who may initiate these procedures defined?	4		
	f. Steps required to correct or avoid deviation from operating limits and consequences of the deviation	4		
	g. Startup following a turnaround	4		
	h. Safety systems and their functions	4		
	i. IOW limits and corrective actions/communication required when those limits are exceeded	15		
4	Operating training covers the IOW concepts and provide the operators with an understanding of the importance of IOWs related to the RBI program and understand their role in the program	10		
5	a. Are key process parameters that may affect equipment integrity (i.e. IOWs) identified and monitored to determine whether operations are maintained within established reliability limits?	5		
	b. Are systems in place that alert appropriate personnel when operation exceeds IOW limits?	4		
	c. Are response protocols established and used in a timely manner when IOW limits are exceeded?	4		

6	An unbiased evaluation is made of the level of compliance with written operating procedures on a periodic basis?	10		10 pts for having a periodic evaluation program. +3 points for performing the reviews once every 2 years or more frequent
<b>Total for Section</b>		100	0	

**Table 2.A.5 – Mechanical Integrity**

Item	Question	Possible Score	Actual Score	Scoring Guidance
1	Has a written inspection program for the facility been developed that includes the following elements:			
	a. All equipment needing inspection has been identified including at minimum: tanks, pressure vessels, piping and piping components, and pressure relief devices?	5		
	b. The responsibilities to conduct the inspections have been assigned?	1		
	c. The inspection methods and locations have been specified for all equipment in the program?	3		
	d. Inspection interval basis have been established for all equipment in the program (time based, condition based, RBI)?	3		
	e. Inspection reporting requirements have been defined?	1		
2	Is there a complete, up-to-date, central storage location for all inspection program information available to everyone who works with the process?	3		2 pts for central location + 1 pt for controlled access with appropriate availability
3	Is there a permanent and progressive record for all equipment in the program that includes all of the following:			
	a. Manufacturers' data reports and other pertinent design data records	1		
	b. Equipment drawings	1		
	c. Results of all inspections, repairs, alterations, or re-ratings that have occurred to date	3		0-3 depending on completeness of records
4	Does the written inspection program for the Facility require an appropriate level of review and authorization prior to any permanent changes in inspection interval basis or methods and testing procedures?	3		
5	Have adequate inspection checklists been developed, are in use and are maintained?	1		

Item	Question	Possible Score	Actual Score	Scoring Guidance
6	<p>Are all inspections, tests and repairs performed on the process equipment being documented and documentation reviewed for quality and consistency in a timely manner, including all of the following information:</p> <ul style="list-style-type: none"> <li>a. The date of the inspection</li> <li>b. The name of the person who performed the inspection</li> <li>c. Identification of the equipment inspected</li> <li>d. A description of the inspection or testing</li> <li>e. Assessment of identified defects based on company established protocol</li> <li>f. The results of the inspection</li> <li>g. All recommendations resulting from the inspection</li> <li>h. A date and description of all maintenance performed</li> <li>i. RBI effectiveness is correctly/consistently applied and assigned for each RBI damage mechanism addressed</li> </ul>	3		+ 1/3 pt for each item, round up
7	Does the written inspection program for the Facility include an established inspection effectiveness table based on API RP 581?	2		
8	Does the written inspection program for the Facility require all deficiencies identified in process equipment pressure boundaries be evaluated to determine if corrective action is required and if continued operation is acceptable?	3		
	a. Are decisions to continue to operate the equipment based on sound engineering assessment such as fitness for service?	2		
	b. If corrective actions are required is a system used to determine priorities for action and tracking to completion ahead of established due dates?	1		
9	Has all equipment within the Process Unit(s) been evaluated for inclusion in the RBI program and where excluded, the basis for exclusion is clearly documented?	3		
10	a. Does the written inspection program for the Facility include a formal, external visual inspection program?	2		
	b. Are all the following factors considered in the external visual inspection program: the condition of the outside of equipment, insulation, painting/coatings, supports and attachments, and identifying mechanical damage, corrosion, vibration, leakage or improper components or repairs, skirt, grounding wire, ladders, platforms, decks, bolted connections, gasket conditions, flange makeup, etc.?	2		
	c. Based on the inspection program for the Facility, does all equipment in the program receive a visual external inspection at the required interval (or deferred date if there is an approved deferral)?	1		0 pts if there are a significant number of overdue inspections.

Item	Question	Possible Score	Actual Score	Scoring Guidance
11	Based on the inspection program, do all pressure vessels in the unit receive an internal, or detailed external inspection using appropriate nondestructive examination procedures, as required by the applicable code/standard/jurisdictional requirements (or deferred date if there is an approved deferral)?	5		2 pt for having inspections set up. +1 pt for having process to approve NDE in lieu of internal inspection +2 pts for not having past due inspections
12	a. Has each item of process equipment been reviewed by appropriate personnel to identify the probable causes of damage or failure?	2		
	b. Has this information been used to establish the inspection methods, locations, and frequencies and the preventive maintenance programs?	3		
	c. Have defect limits for expected damage mechanisms been established based on sound engineering assessments?	2		
13	a. Is a formal program for condition monitoring of Stationary equipment been established for the Facility?	3		
	b. When the locations for condition monitoring are chosen,			
	1. Is the likelihood and consequence of failure considered?	1		
	2. Is localized corrosion and erosion considered?	1		
	c. Are condition monitoring locations clearly marked on inspection drawings and on the equipment to allow repetitive measurements at precisely the same locations?	2		
	d. Are condition monitoring surveys up to date?	2		
	e. Are the results used to calculate a representative corrosion rate for RBI assessments?	2		
14	Procedures and processes are in place to ensure thickness and wall loss measurements used for RBI analysis are accurate?	4		
15	Has the maximum allowable working pressure (MAWP) been established for all piping systems and equipment, using applicable codes and current operating conditions?	1		
16	Does the program require formal risk evaluation and approval of date changes for inspection and repair plans (i.e., deferrals) related to operational needs?	3		1 pt for written procedure 1 pt for detailed risk evaluation guidance 1 pt for demonstrable full adherence
17	a. Have all employees involved in maintaining and inspecting the equipment been trained in all procedures applicable to their job tasks to ensure that they can perform the job tasks effectively?	1		
	b. At completion of the training described above, are formal methods used to verify that the employees understand what they were trained on?	1		
18	Are inspectors certified for performance in accordance with applicable industry codes and standards (e.g. API 510, 570 and/or 653)?	2		

Item	Question	Possible Score	Actual Score	Scoring Guidance
19	Does the Facility have a quality assurance program for construction and maintenance to ensure that:			
	a. Proper materials of construction are used?	2		
	b. Fabrication, welding and inspection procedures are proper?	2		
	c. Equipment maintenance and repairs are completed in compliance with codes and standards?	1		
	d. Flanges are properly assembled and tightened?	1		
19	e. Replacement and maintenance materials are properly specified, inspected and stored?	1		
	Are systems in place, such as written requirements with appropriate approval, sufficient to ensure that all design repair and alteration done on equipment types in the program is done in accordance with the code to which the equipment was built, or in-service repair and inspection code?	3		2 pts for meeting some requirements 3 pts for all of the above
	Are systems in place, such as written requirements with appropriate approval, sufficient to ensure that new equipment design, for all equipment types in the program, is done in accordance with the applicable codes and standards?	3		2 pts for meeting some requirements 3 pts for all of the above
	Are RBI assessments updated and maintained in a timely manner after events that would change the basis of the risk evaluation so that the most recent process, inspection, and maintenance information is included?	5		3 pts for periodic full-unit re-assessments before the end of the plan period +1 pt for evergreening after each inspection event +1 pt for evergreening after process excursions and applicable MOCs
	If credit for cathodic protection being taken in RBI, is the cathodic protection system inspected on a periodic basis and maintained in effective status?	3		If CP is not applicable to Facility equipment, full credit may be taken
	<b>Total for Section</b>	<b>100</b>	<b>0</b>	

Table 2.A.6 – Equipment Failure Investigation

Item	Question	Possible Score	Actual Score	Scoring Guidance
1	a. Is there a written equipment failure investigation procedure that includes both loss of containment and threats to loss of containment?	5		
	b. Does the procedure require that findings and recommendations of investigations be addressed and resolved promptly? Do records demonstrate timely completion?	5		
2	Does the procedure require that the investigation team include:			
	a. A member trained in root cause analysis techniques?	8		

	b. Cross-functional attendees competent in their area (corrosion, inspection, operations, equipment design, etc.)?	5		
3	Indicate whether the investigation procedure requires an investigation of the following items with the results recorded on a standard form(s):			
	a. Loss of primary containment	8		
	b. Unexpected equipment damage	6		
	c. Chronic equipment failures	3		
4	Is there a standard form(s) for equipment failure investigation that includes the following information?			
	a. Date of failure	1		
	b. Investigation attendees	1		
	c. Description of the incident	1		
	d. Underlying causes of the incident	5		
	e. Evaluation of the potential severity and probable frequency of recurrence	2		
	f. Recommendations are generated to prevent recurrence not just in the exact incident scenario, but more globally where a similar occurrence is possible on other equipment or units	10		
5	Based on a review of plant records (leaks, lost production, etc.), to what degree does it appear that the established equipment failure investigation procedures are being followed?	5		5 points: >95% of the time 3 points: Only major impacts
6	Are appropriate inspection or engineering people required to be involved in a failure analysis to identify the conditions or practices that caused the failure?	5		
7	Are incident investigation reports reviewed with all affected personnel whose job tasks are relevant to the incident findings, including contract employees, where applicable?	5		
8	Are incident or accident reports or report conclusions transmitted to other sites that operate similar facilities within the company?	5		
9	a. Do the procedures for incident reporting require that the findings related to stationary equipment loss of primary containment include a review of the RBI data, IOWs, and corrosion management programs to ensure the RBI assessment, IOW program and corrosion management documents accurately reflect the active damage mechanisms, rate of degradation and consequence.	10		
	b. RBI data is updated as a result of incident investigations that show the RBI data is not accurate.	10		
	<b>Total for Section</b>	<b>100</b>	<b>0</b>	