Fixed Equipment- Probability of Internal Failure Classification

Table of Contents

1.0 SCOPE 3

2.0 REFERENCES 3

3.0 DEFINITIONS 3

4.0 GENERAL 3

5.0 IMPLEMENTATION 4

5.1 General 4

5.2 Specific 4

5.2.1 Corrosivity of Process 4

5.2.2 Corrosion Rate Half Life 5

5.2.3 Internal Inspection 5

5.2.4 Mean Time Before Failure 6

5.2.5 Environmental Cracking 6

5.2.6 Probability of Failure 6

Attachment 1- Rules for Establishing Probability of Internal Failure Numerical Rankings

Equipment Probability of Internal Failure

Guidelines

1.0 **SCOPE**

1.1 This guideline, and the attached "Rules for Establishing Probability of Internal Failure Numerical Ratings," rev. 3, from now on called the "Rules," are used to establish numerical ratings for the probability of failure (POF) of fixed equipment in chemical processing plants, based on internal considerations.

1.2 Equipment covered by these rules includes all process fixed equipment items designed and constructed to ASME Section VIII, Rules for Construction of Pressure Equipment, divs. 1 and 2.

1.3 The rules do not apply to storage tanks built to API Standards 650 or 620, to rotating equipment, or to piping.

2.0 REFERENCES

2.1 Risk Based Inspection- Development of Guidelines, CRTD-Vol. 20-1, ASME.

2.2 API Standard 510, Pressure Vessel Inspection Code.

3.0 DEFINITIONS

None.

4.0 GENERAL

4.1 This document, and the attached "Fixed Equipment- Rules for Establishing Probability of Internal Failure Numerical Ratings," rev. 3 is intended for use in establishing numerical ratings for internal probability-of-failure for fixed equipment items.

4.2 The attached Rules were developed using concepts associated with qualitative risk-based inspection methods, to the extent possible, as detailed in Risk Based Inspection- Development of Guidelines, CRTD-Vol. 20-1, ASME. Inspection criteria in API Standard 510, Pressure Vessel Inspection Code was also incorporated, where appropriate.

4.3 The POF numerical rating is meant to be an indicator of an equipment item's absolute susceptibility to failure. It is intended as a convenient and reproducible means for establishing equipment inspection priorities, based on knowledge. As such, it facilitates the most efficient use of finite inspection monies and personnel where 100% inspection is not practical.

4.4 The Rules are based heavily on detailed inspection histories, knowledge of corrosion processes, and knowledge of normal and upset process conditions. As such, the equipment ratings will not stay constant, but require updating as additional knowledge is gained. Maximum use of the rules depends on the development and implementation of inspection systems that permit the capture, documentation, and retrieval of inspection, maintenance, and corrosion/failure mechanism information.

5.0 IMPLEMENTATION

5.1 General

5.1.1 Based on inspection, corrosion, and failure attributes, as detailed in the Rules, equipment items are assigned a numerical POF rating of one to three. The numerical POF rating is used in a matrix with a degree of hazard rating to establish an equipment classification number (ref. 1). The classification number sets maximum inspection intervals and facilitates equipment inspection priority strategies, based on finite inspection budgets, time requirements, and/or personnel resources.

5.2 Specific

5.2.1 Corrosivity of Process

5.2.1.1 Process corrosivity is divided into three corrosion rate intervals, in mils per year (mpy). The corrosion rate information is used with remaining corrosion allowance (RCA) information to calculate a corrosion rate half life (CRHL) for the equipment item.

5.2.1.2 Where actual corrosion rate data is available from ultrasonic thickness surveys, that data is used.

5.2.1.3 Where ultrasonic thickness data is not available, corrosion rates can be estimated, based on personal knowledge or from

corrosion literature.

5.2.1.4 Determining useful corrosion rates requires knowledge of the process environment vs. materials of construction interactions. Estimated corrosion rates should be based on both bulk and localized corrosion considerations. Where it is believed that a potential for localized, accelerated corrosion exists, based on corrosion knowledge, worse case corrosion rates should be based on that potential until internal inspections can be performed.

5.2.1.5 Where equipment items include one or more materials or process combinations, worse case corrosion rates should govern. Typical examples of this situation include distillation columns with dual metallurgy shell courses, and shell and tube exchangers.

5.2.2 Corrosion Rate Half Life

5.2.2.1 Using actual or estimated corrosion rates and remaining corrosion allowance information, a corrosion rate half life is calculated according to the following formula:

$$CRHL = (0.5 \times RCA) \div mpy$$

5.2.2.2 The calculated CRHL, in years, is used to establish a CRHL rating from one to three, based on the intervals defined in Section II of the Rules.

5.2.3 Internal Inspection

5.2.3.1 An internal inspection rating number is assigned to the equipment item, based on the parameters in Section III of the Rules.

5.2.3.2 For distillation columns, an internal inspection is not considered to have been conducted unless tray manways are removed, or packing is removed, and the column adequately cleaned, to permit inspection of the entire column.

5.2.3.3 For shell and tube exchangers, and internal inspection is not considered to have been conducted, unless the exchanger tubes, or a portion of, are nondestructively inspected.

5.2.4 Mean Time Before Failure

5.2.4.1 A mean time before failure (MTBF) rating is assigned, based on Section IV of the Rules. If failure has not occurred, or an equipment item material of construction was recently upgraded, based on corrosion, an MTBF rating is not assigned.

5.2.4.2 The MTBF rating is particularly appropriate for shell and tube exchangers where the bulk corrosivity of the cooling water is nominally low; however, exchanger tube failures are frequent, based on localized conditions, or cooling water treatment upsets.

5.2.5 Environmental Cracking

5.2.5.1 An environmental cracking propensity rating is established according to Section V of the Rules, based on known process upsets and corrosion knowledge. This rating usually requires a detailed knowledge of the process and corrosion mechanisms.

5.2.6 Probability of Failure

5.2.6.1 Using the numerical ratings established in Sections 2.0 through 5.0 of this guideline, an overall POF rating for the equipment item is established, according to Sections A through C in the POF table in the Rules.

5.2.6.2 The final POF rating is assigned according the boolean logic variables in the table.

Probability of Internal Failure Classification Rules

Probability of Failure Input Parameters

I. **Corrosivity of Process**

A. Bulk process is essentially non-corrosive to equipment materials-of-construction with documented corrosion rates of 0-10 mils per year (MPY) and with no localized, unpredictable corrosion anticipated.

B. Bulk process can exhibit moderate corrosion rates of 10-20 MPY at areas of velocity, turbulence, etc. in locations not predictable or accessible to external inspection.

C. Potential exists for corrosion rates as high as 20-50 MPY in locations not predictable or accessible to an external inspection.

II. **Corrosion Rate Half-Life**

1. (0.5 x RCA)[1] ÷ mpy = 1 - 5 years

2. (0.5 x RCA) ÷ mpy = 6 - 10 years

3. (0.5 x RCA) ÷ mpy = 11 - 20 years

III. **Internal Inspection**

1.00 Equipment older than 10 years, no internal inspection within last 10 years.

1.04 Newly installed equipment with less than 5 years of service and in process corrosivity categories IB or IC with no inspection.

1.05 Unresolved defect or deficiency, observed, detected, or measured during a previous inspection, resulting in a repair recommendation to a pressure boundary, or a recommendation to monitor or replace during the next scheduled shutdown.

1.06 Exchangers only- No MFE or eddy current tube inspection.

2.01 Equipment less than 10 years old in corrosivity category IA with no inspection.

2.02 One internal inspection within 10 years with no reportable findings .

---

[1] RCA= Remaining corrosion Allowance

3.00 Two or more internal inspections with no reportable findings, the last inspection within ten years.

IV. **Mean Time Before Failure (MTBF)**

1.00 0 - 10 years.
2.00 11 - 15 years.
3.00 16 - 20 years.

V. **Environmental cracking (process only).**

1.02 SCC cracking potential during normal operation.

1.03 SCC potential following a documented process upset.

3.00 No SCC potential.

PROBABILITY OF FAILURE RATING

A. Probability of Failure = 1

1.00 Corrosion-rate half-life equals 0 - 5 years.

or

1.00 MTBF equals 0 - 10 years.

or

1.01 No internal inspection performed within last ten years..

or

1.02 SCC potential during normal operation.

or

1.03 Documented process upset with SCC potential since last internal inspection.

or

1.04 Newly installed equipment with less than 5 years of service and in process corrosivity categories IB or IC.

or

1.05 Unresolved defect or deficiency observed, detected, or measured during previous inspection resulting in a repair recommendation to a pressure boundary, or a recommendation to monitor or replace during the next scheduled shutdown.

or

1.06 Exchangers only- No MFE or eddy current inspection.

B. Probability of Failure = 2

2.00 Corrosion-rate half-life equals 6 - 10 years.

and

2.00 MTBF equals 11 - 15 years.

or

2.01 Newly installed equipment with < five years service and no inspection.

or

2.02 One internal inspection within last ten years with no reportable findings.[23]

C. Probability of Failure = 3.

3.00 No SCC potential.

and

3.00 Corrosion-rate half- life equals 11+ years.

and

3.00 MTBF equals 16-20 years.

and

3.00 Two or more documented internal inspections with no reportable findings. (1) (2)

[2] For exchangers, defined as including an MFE or an eddy current tube inspection.

[3] For towers, defined as removing all tray manways and visually inspecting the entire column after cleaning.