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Addendum 1

Below is a summary of the changes made in this addendum.

Part 1

— Editorial changes and corrections
— Modified definition in Section 3.1.48
— Added/modified acronyms
— Combined generic failure frequency discussion from 4.1.2.1 into Part 2 discussion
— Updated example in Section 4.3.2.2 a) and b)
— Changed use of CA as variable name for consequence area throughout document
— Modified NOTE 1 in Tables 4.1/4.1M and 4.2/4.2M
— General clarifications and corrections in Section 7
   a. Modified Equation (1.31) (now 1.30)
   b. Added burst pressure discussion to Section 7.2.5 a)
   c. Added burst pressure consideration to Table 7.3
   d. Added Table 7.4 for design margins
   e. Added basis for example in Figure 7.6
— General clarifications and corrections in Section 8
   a. Correction Equation (1.79) (now (1.77)) and removed Equations (1.80) and (1.81) and text
   b. Removed software related terminology and references in Table 8.1
   c. Added notes to Table 8.5
   d. Added/modified notes in Table 8.6

Part 2

— Editorial changes and corrections
— Revised generic failure frequency discussion in Section 3.3 with text moved from Part 1, Section 4.1.2.1
— Equations (2.2) and (2.3): Changed definition for combining internal and external thinning damage based on general and local behavior
— Corrected total generic failure frequency for Tank650/TankBottom in Table 3.1
— Corrected question count for Safe Work Practices and total in Table 3.3
— Added consideration for cladding/weld overlay thickness in Section 4.5.7, Step 1
— Modified Equation (2.11) for cladding/weld overlay age
— Modified/simplified Step 6 determining the Ar factor calculation with and without cladding/weld overlay (combining 2-4 and Equations (2.13) through (2.15) into one calculation step and equation
— Added definition for base material thickness, $t_{bm}$, and cladding/weld overlay thickness, $t_{csm}$, to nomenclature in Section 4.6
— Section 15, *External Corrosion Damage Factor—Ferritic Component*
  a. Modified climate driver definitions and names in Sections 15.2 and 15.6.2, and driver description in Tables 15.1 and 15.2/15.2M
  b. Added consideration for measured wall loss, $L_e$, in Section 15.6.4, Step 4
  c. Modified age$_{ke}$ definition in 15.7, *Nomenclature*
  d. Added measured wall loss, $L_e$, from external corrosion definition to 15.7 *Nomenclature*
— Section 16, *Corrosion Under Insulation Damage Factor—Ferritic Component*
  a. Modified climate driver definitions and names in Section 16.2 and driver description in Tables 16.1 and 16.2/16.2M
  b. Added consideration for measured wall loss, $L_e$, in Section 16.6.3, Step 4
  c. Modified age$_{ke}$ definition in 16.7, *Nomenclature*
  d. Added measured wall loss, $L_e$, from external corrosion definition to 16.7 *Nomenclature*
— Section 17, *External Chloride Stress Corrosion Cracking Damage Factor—Austenitic Component*
  a. Added inspection explanation in Section 17.6.3, Step 3
  b. Modified driver definition in Tables 17.1 and 17.2
— Section 18, *External Chloride Stress Corrosion Cracking Under Insulation Damage Factor—Austenitic Component*
  a. Added inspection explanation in Section 18.6.3, Step 3
  b. Modified driver definition in Tables 18.1 and 18.2

**Annex 2.A**
— Corrected Possible Score points addition for Table 2.A.6, *Safe Work Practices*

**Annex 2.B**
— Corrected equation for NH$_4$HS concentration in Table 2.B.7.1, *Alkaline Sour Water Corrosion—Basic Data Required for Analysis*, for wt% NH$_4$HS based on wt% NH$_3$
— Corrected $C_3$ and $C_4$ factors in Table 2.B.11.3, *pH Calculation Parameters*

**Annex 2.C**
— Added/modified description of inspection for PRDs in Table 2.C.3.1, *Inspection and Testing Effectiveness for Pressure-relief Devices*

**Part 3**
— Editorial changes and corrections
— Modified Type 1 Fluid description in Section 4.1.5 b), Section 4.8.8 l), Step 8.12, and Section 4.8.8 n), Step 8.14
— Redefined diameter, $d_n$, for each hole size to a maximum of the component diameter in Sections 4.2.2 a) and 4.3.4 b)
— Modified definition of continuous release for blending based on release type in Sections 4.8.5 a) and 4.8.5 b)
— Modified/simplified Equations (3.63) and (3.64) in Section 4.9.6 (does not change result)
— Added clarification for toxic consequences in the case of an instantaneous release using 3-minute continuous release factors in Section 4.9.15, Step 9.4.3
— Added calculation basis in Section 4.10.2 (1st paragraph)
— Clarified acid and caustic leaks are modeled as liquid and gas in Section 4.10.3 (1st paragraph)
— Clarifies liquid releases for acid and caustic releases in Section 4.10.6.2
— Corrected Equation (4.12.6) for financial impact based on personnel injury
— Corrected Equation (3.92)
— Added energy efficiency correction factor, $\text{eneff}_n$, definition to Section 4.13, *Nomenclature*
— Added representative fluids to Tables 4.1, 4.2/4.2M, 4.8/4.8M, and 4.9/4.9M to allow modeling of 100% toxic fluids without a flammable process carrier
— Redefined diameter, $d_n$, for each hole size to a maximum of the component diameter in Table 4.4/4.4M
— Corrected Equation (3.209) in Section 6.3.2, *Atmospheric Storage Tank Shell Course*
— Added definitions for the following variables in Section 6.13, *Nomenclature*:
  — $\mathit{mass}_{\mathit{total}}$
  — $n^h$
  — $\mu_w$

Annex 3.A
— Editorial changes and corrections
— Added instantaneous release description for toxic consequences in Section 3.A.3.6.9.3

Annex 3.B
— No changes or corrections
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Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.
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8 HEAT EXCHANGER TUBE BUNDLES
Risk-Based Inspection Methodology  
Part 1—Inspection Planning Methodology

1 Scope

1.1 Purpose

This recommended practice, API 581, *Risk-Based Inspection Methodology*, provides quantitative procedures to establish an inspection program using risk-based methods for pressurized fixed equipment including pressure vessel, piping, tankage, pressure-relief devices (PRDs), and heat exchanger tube bundles. API 580, *Risk-Based Inspection* provides guidance for developing risk-based inspection (RBI) programs on fixed equipment in refining, petrochemical, chemical process plants, and oil and gas production facilities. The intent is for API 580 to introduce the principles and present minimum general guidelines for RBI, while this recommended practice provides quantitative calculation methods to determine an inspection plan.

1.2 Introduction

The calculation of risk outlined in API 581 involves the determination of a probability of failure (POF) combined with the consequence of failure (COF). Failure is defined as a loss of containment from the pressure boundary resulting in leakage to the atmosphere or rupture of a pressurized component. Risk increases as damage accumulates during in-service operation as the risk tolerance or risk target is approached and an inspection is recommended of sufficient effectiveness to better quantify the damage state of the component. The inspection action itself does not reduce the risk; however, it does reduce uncertainty and therefore allows more accurate quantification of the damage present in the component.

1.3 Risk Management

In most situations, once risks have been identified, alternate opportunities are available to reduce them. However, nearly all major commercial losses are the result of a failure to understand or manage risk. In the past, the focus of a risk assessment has been on-site safety-related issues. Presently, there is an increased awareness of the need to assess risk resulting from:

a) on-site risk to employees,

b) off-site risk to the community,

c) business interruption risks, and

d) risk of damage to the environment.

Any combination of these types of risks may be factored into decisions concerning when, where, and how to inspect equipment.

The overall risk of a plant may be managed by focusing inspection efforts on the process equipment with higher risk. API 581 provides a basis for managing risk by making an informed decision on inspection frequency, level of detail, and types of nondestructive examination (NDE). It is a consensus document containing methodology that owner–users may apply to their RBI programs. In most plants, a large percent of the total unit risk will be concentrated in a relatively small percent of the equipment items. These potential higher risk components may require greater attention, perhaps through a revised inspection plan. The cost of the increased inspection effort can sometimes be offset by reducing excessive inspection efforts in the areas identified as having lower risk. Inspection will continue to be conducted as defined in existing working documents, but priorities, scope, and frequencies can be guided by the methodology contained in API 581.

This approach can be made cost-effective by integration with industry initiatives and government regulations, such as Process Safety Management of Highly Hazardous Chemicals (OSHA 29 CFR 1910.119), or the EPA risk management programs for chemical accident release prevention.