RECORD OF REVISIONS

Rev	Date	Description	POC	RM
0	9/17/2014	Initial issue. Previously was Chapter 17, Section I, rev. 3, App E.	Ari Ben Swartz, *ES-EPD*	Larry Goen, *ES-DO*

Contact the Standards POC for upkeep, interpretation, and variance issues.

Chapter 17	**Pressure Safety POC and Committee**

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This Risk-Based Evaluation process is used in Chapter 17 Section EXIST and may be used in other situations (e.g., ASME, NASME) where allowed by those sections or with a variance (Form 2137).[1]

Guidance: The risk-based engineering evaluation evaluates the systems and determines if there is a risk to the worker (and equipment). A risk-based engineering evaluation is normally applied to non-hardware issues. A system that has known hardware issues will not likely benefit from this type of analysis.

A. Definitions

1. **Engineering Evaluation** – The Risk-Based Engineering Evaluation is the process of reviewing a pressure system for adequate pressure system integrity and determining necessary corrective actions to mitigate risk to acceptable level based on best engineering practices.
2. **Consequence** – The potential outcome from an event. There may be more than one consequence from an event.
3. **Probability** – The relative frequency with which an event is likely to occur within the time frame under consideration.
4. **Acceptable Risk** – A Qualitative Risk (QR) number of 4 or higher as shown on Table EXIST-1-4, Qualitative Risk, below. Qualitative Risk shall be controlled to QR number of 4 or higher.

B. Baseline Criteria

1. The Risk-Based Engineering Evaluation applies only to systems that have correctly sized relief protection.

C. Engineering Evaluation

1. The Risk-Based Engineering Evaluation is a three step process. This process applies to evaluation of Risk Level 2 and 3 deficiencies, as defined above; Risk Level 1 deficiencies must be corrected in accordance with the requirements stipulated above.

[1] Process is based on API RP 580-2009 Risk-Based Inspection methodology

a. Using system information generated from the walk down team efforts and other sources, and ESM Chapter 17 requirements, the engineer generates a Qualitative Risk of each deficiency.

b. The Qualitative Risk is then compared to the Acceptable Risk (i.e., risk number of 4 or higher).

c. If the Qualitative Risk is greater than the Acceptable Risk (i.e., a risk number lower than 4), then either the consequence or probability must be adjusted to achieve a risk number of 4 or higher.

2. An engineering evaluation of the pressure system shall be performed by personnel meeting the qualification requirements for a pressure system designer and approved by a qualified PSO (*see Section GEN)* with Risk Evaluation training.

3. The engineering evaluation shall be an analysis and examination of the pressure system to determine the system integrity.

4. The Risk-Based Engineering Evaluation analysis shall be included with the pressure system documentation.

5. The Risk-Based Engineering Evaluation shall ensure that hazards and dominant contributors to risk are controlled according to the following:

a. Eliminate accident scenarios (e.g., eliminate hazards or initiating events by design).

b. Reduce the likelihood of accident scenarios through design and operational changes (hazard control).

c. Reduce the severity of accident consequences (hazard mitigation).

d. Improve the state-of-knowledge regarding key uncertainties that drive the risk associated with a hazard (uncertainty reduction to support implementation of the above strategies).

6. The control(s) shall be based on the level of risk associated with that hazard. Some risks may require a combination of several different approaches to prevent, mitigate, and/or control the risk.

7. Controls shall be in applied the following order of precedence:

a. Engineered controls,

b. Administrative controls,

c. Personal protective equipment.

D. Qualitative Risk (QR)

1. The Risk-Based Engineering Evaluation shall, as a first step, use a Qualitative Risk based approach to evaluate adequacy of pressure system integrity.

2. The qualitative risk evaluation shall identify:

a. the system(s),

b. the hazard(s) (deficiency,

c. the probability assessment,

d. the consequence of failure evaluation, and

e. the subsequent QR number (see Table EXIST-1-3).

3. The Qualitative Risk based evaluation shall be based on probability and consequence of a single-point system failure for each deficiency observed.

Table EXIST-1-1 Probability factors to be considered

a. corrosion potential (crevice corrosion, general, galvanic, etc…)
b. materials of construction (composite, plastic, steel, brass, etc...)
c. material compatibility (lubricants, seals, and general materials)
d. oxygen systems
e. erosion potential
f. fatigue cycles (cycle life)
1) low-cycle fatigue (where significant plastic straining occurs).
2) high-cycle fatigue (where stresses and strains are largely confined to the elastic region)
g. size (contained energy)
h. human error
i. operating history
j. damage mechanisms
k. operation in creep range
l. stress intensification factors; for example, cracks or acute angles in pressure boundaries
m. available documentation
1) welding
2) code pressure test
n. documentation of ASME code fabrication
o. MAWP and design pressure as used in code calculations
p. design temperature
q. corrosion allowance determination
r. code required calculations (as applicable)
s. minimum wall thickness
t. nozzle reinforcement
u. thermal load calculations
v. seismic calculations
w. support structure
x. wind loading
y. piping flexibility analysis
z. cyclic loading calculations
aa. other static loadings (static fluid head)
bb. other dynamic loadings
cc. historical operational documentation
1) corrosion rate (mils/year) (used to determine inspection interval)
2) locations and dates of thickness measurements
3) year of construction
4) date of original installation
5) date of first use
6) out of service periods (used to determine inspection interval)
7) discrepancy conditions
8) a comprehensive chronological record of maintenance history
9) history of repair – objective evidence required for ASME code stamped items.
10) history of alterations – objective evidence required for ASME code-stamped items.
11) historical inspections records of NDE
12) applicable variances/waivers
13) fabrication documentation
14) leak test records
15) maintenance sheet
16) daily logs
17) boiler records – water treatment, maintenance, and boiler appurtenances
18) engineering evaluations as required by this chapter

4. Consequences of failure to be considered include the following safety and health issues:
   a. Chemical toxicity
   b. Physical hazards (e.g., projectiles)
   c. Flammability
   d. Radioactivity
   e. Asphyxiation hazards
   f. Volume
   g. Failure Mode
      1) Brittle fracture failure mode
      2) Leak before burst failure mode
   h. Inhabited areas
   i. Shielding (glove box, fume hood, test cell)
5. Other issues to consider include:
   a. Mission criticality
   b. Economic impact
   c. Schedule
   d. Environmental impact

E. Hazard Mitigation

1. Based on the results of the probability evaluation, a probability bin is selected as defined in Table EXIST-1-2, Failure Probability.
2. Based on the results of the consequence evaluation, a consequence bin is selected as defined in Table EXIST-1-3, Consequence of Failure.
3. Enter Table EXIST-1-4, Qualitative Risk Evaluation, and locate the QR number that corresponds to the intersection of the probability bin (A through E) and consequence bin (I through V).
4. If the QR number rating is less than 4 (i.e., 1, 2, or 3), then the Risk-Based Engineering Evaluation shall provide a methodology to reduce risk through correction of deficiencies or introduction of additional controls. Refer to Table EXIST-1-5, "Action Matrix for Existing (Legacy) Pressure System Deficiencies" *QR Action Matrix*, to determine the approved actions to correct the issues.

Table EXIST-1-2 Failure Probability

Level	Description	Qualitative
A (Frequent)	Frequent	Likely to occur immediately
B (Probable)	Probable	Probably will occur in time
C (Occasional)	Occasional	May occur in time
D (Remote)	Remote	Unlikely to occur
E (Improbable)	Improbable	Improbable to occur

Table EXIST-1-3 Consequence of Failure

Category	Description	Examples
I	Major	Fatalities, and/or major long-term environmental impact
II	Serious	Serious injuries, and/or significant environmental impact
III	Significant	Minor injuries, and/or short-term environmental impact
IV	Minor	First aid injuries only, and/or minimal environmental impact
V	Insignificant	No significant consequence

Table EXIST-1-4 Qualitative Risk (QR) Determination

			Probability				
			A	**B**	**C**	**D**	**E**
			Frequent	**Probable**	**Occasional**	**Remote**	**Improbable**
Consequence	**I**	**Major**	1	1	1	2	3
	II	**Serious**	1	1	2	3	4
	III	**Significant**	1	2	3	4	5
	IV	**Minor**	2	3	4	5	6
	V	**Insignificant**	3	4	5	6	7

5. The following risk-based engineering evaluation Table EXIST-1-5 applies only to legacy systems (built prior to March 10, 2009). All other systems are required to meet ESM Chapter 17 requirements for new in construction in ASME or NASME.

Table EXIST-1-5

Action Matrix for Existing (Legacy) Pressure System Deficiencies

Item	Deficiency	QR 1	QR 2	QR 3
1.	Vessel rating; rating unknown (unknown design pressure or MAWP)	1) Replace item with rated item, or 2) Perform code-compliant calculations to establish MAWP	1) Replace item with rated item, or 2) Perform code-compliant calculations to establish MAWP	1) Replace item with rated item, or 2) Perform code-compliant calculations to establish MAWP, or 3) Perform minimum wall calculation, perform field verification of minimum wall, and perform code-compliant pressure test
2.	Piping component rating; rating unknown (unknown design pressure or MAWP)	1) Replace item with rated item, or 2) Perform code-compliant calculations to establish MAWP	1) Replace item with rated item, or 2) Perform code-compliant calculations to establish MAWP	1) Replace item with rated item, or 2) Perform code-compliant calculations to establish MAWP, or 3) In cases where published manufacturer's literature provides a maximum operating pressure: determine appropriate system design pressure, confirm that manufacturer's maximum pressure condition is greater than system design pressure, and perform code-compliant pressure test
3.	Missing or out of date system schematic	Create or update sketch or drawing in accordance with Section V of this Chapter	Create or update sketch or drawing in accordance with Section V of this Chapter	Create or update sketch or drawing in accordance with Section V of this Chapter
4.	Materials of construction not suitable for service	Replace item with correct material	Replace item with correct material	1) Replace item with correct material, or 2) Provide shielding, or 3) Control personnel exposure to hazard

Item	Deficiency	QR 1	QR 2	QR 3
5.	Code stamped vessel code data report not available (U1, U1A, P1, etc.)	1) Obtain manufacturer's shop drawing and verify that vessel has not been modified 2) If manufacturer's shop drawing is not available, obtain written statement from system owner that vessel has not been modified 3) If vessel has been modified, perform code calculations to confirm that the vessel is still code compliant 4) Replace vessel	1) Obtain manufacturer's shop drawing and verify that vessel has not been modified 2) If manufacturer's shop drawing is not available, obtain written statement from system owner that vessel has not been modified 3) If vessel has been modified, perform code calculations to confirm that the vessel is still code compliant 4) Replace vessel	1) Obtain manufacturer's shop drawing and verify that vessel has not been modified 2) If manufacturer's shop drawing is not available, obtain written statement from system owner that vessel has not been modified 3) If vessel has been modified, perform code calculations to confirm that the vessel is still code compliant 4) Replace vessel
6.	Non-ASME code stamped vessel design and fabrication documentation not in compliance with ASME Section VIII			
6.1.	Code compliant design calculations, including: minimum wall thickness, corrosion allowance, weld efficiency rating, support structure loading, nozzle calculations	1) Perform code-compliant calculations (require review by Professional Engineer), or 2) Replace with code-stamped vessel	1) Perform code-compliant calculations (require review by Professional Engineer), or 2) Replace with code-stamped vessel	1) Perform code-compliant calculations (require review by Professional Engineer), or 2) Replace with code-stamped vessel , or 3) Provide shielding or control personnel exposure to vessel when pressurized
6.2.	Pressure Test Report	1) Perform code pressure test	1) Perform code pressure test	1) Perform in-service leak test, or 2) Provide shielding or control personnel exposure when pressurized

Item	Deficiency	QR 1	QR 2	QR 3
6.3.	Modification or alteration calculations	1) Perform code compliant calculations to verify proper modification or alteration, or 2) Replace with code-stamped vessel	1) Perform code compliant calculations to verify proper modification or alteration, or 2) Replace with code-stamped vessel	1) Perform code compliant calculations to verify proper modification or alteration, or 2) Replace with code-stamped vessel, or 3) Provide shielding or control personnel exposure when pressurized
6.4.	Non-Destructive Evaluation (NDE) data reports	1) Perform NDE as required by code	1) Perform NDE as required by code, or 2) Perform code pressure test	1) Perform NDE as required by code, or 2) Perform in-service leak test, or 3) Provide shielding or control personnel exposure to system when pressurized
7.	Piping System design and fabrication documentation not in compliance with applicable B31 piping code			
7.1.	Piping System Code required calculations; for example, in B31.3: 301.10 cyclic effects, 304 pressure design, 304.3.5 external forces, thermal expansion and contraction, dead and live loads, 319 flexibility analysis, 319.2.1(c) wind loading, and seismic loading; see specific code for additional detail.	1) Perform code-compliant calculations	1) Perform code-compliant calculations	1) Perform code-compliant calculations 2) Provide shielding or control personnel exposure to system when pressurized
7.2.	Pressure Test Report	1) Perform code pressure test	1) Perform code pressure test	1) Perform in-service leak test 2) Provide shielding or control personnel exposure to system when pressurized
7.3.	Piping System Non-Destructive Evaluation (NDE) data reports	1) Perform NDE as required by code	1) Perform NDE as required by code, or 2) Perform code pressure test	1) Perform NDE as required by code, or 2) Perform in-service leak test, or 3) Provide shielding or control personnel exposure to system when pressurized
8.	Other	Action reviewed and approved by CPSO	Action reviewed and approved by CPSO	Action reviewed and approved by CPSO

6. Approved Qualitative Risk Evaluation (QRs)
   a. Attached to this document are approved, general qualitative risk evaluations that can be applied to existing systems meeting the LANL definition of legacy. At time of writing, these were:

      EXIST-1a, QR for Inert Gas Cylinders
      EXIST-1b, QR for Low Pressure Steam and Steam Condensate
      EXIST-1c, QR for Compressed Air Systems