

RECORD OF REVISIONS

Rev	Date	Description	POC	RM
0	9/17/14	Initial issue.	Ari Ben Swartz, <i>ES-EPD</i>	Larry Goen, <i>ES-DO</i>
1	6/30/15	A342 changed to Use B31.3 paragraph as written. A345 change based on ASME interpretation. Updates for B31.3-2014.	Ari Ben Swartz, <i>ES-EPD</i>	Larry Goen, <i>ES-DO</i>
2	8/24/15	Admin change to add missing "for ML-4 only."	Ari Ben Swartz, <i>ES-EPD</i>	Larry Goen, <i>ES-DO</i>
3	9/22/23	Update to introductory section to clarify application of NASME for B31.3 systems. Combined Normal and Category D evaluations (formerly NASME-1-A and 1-B) into a single document. Updated Section and Attachment name for revised ESM Ch. 17 format.	Ari Ben Swartz, <i>ES-FE</i>	Dan Tepley, <i>ES-DO</i>

Contact the Standards point of contact (POC) for upkeep, interpretation, and variance issues.

Chapter 17	<u>Pressure Safety POC</u>
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This document is online at <https://engstandards.lanl.gov>

1.0 PURPOSE

This document provides code equivalencies for ASME B31.3 **Non-Metallic** systems (Fluid Categories D and Normal) for use at Los Alamos National Laboratory (LANL). Any of the equivalencies can be applied to a pressure system to provide an approved equivalency to that specific paragraph of B31.3 without applying all the equivalencies. Code paragraphs can be used as written. Any paragraph not listed in the equivalency table shall be used as written. The equivalencies apply to portions of pressures systems that are not ASME BPVC equipment (e.g., boilers, pressure vessels, and air receivers) or supporting piping. The equivalencies cannot be applied to systems with severe cyclic conditions, Category M fluid service, High Pressure fluid service, High Purity fluid service, or Elevated Temperature fluid service (temperature in the creep range). The equivalencies cannot contradict or invalidate facility specific safety basis requirements for credited pressure systems.

2.0 EQUIVALENCY EVALUATION

The risk-based engineering evaluation process used in this attachment is provided in Section 3.0 at the end of this attachment. The Qualitative Risk of the equivalencies provided is 4 or greater (i.e., low).

B31.3 Paragraph	Equivalency Evaluation
Scope and Definitions	
A300 General Statements (B) Responsibilities	Pressure Safety Officer (PSO) Duty Area B may assist and concur with designer and may serve as a designer. Qualified PSO Duty Area B may perform the role as owner’s Inspector delegate if appointed by the Owners Inspector.
A300.1.3 Exclusions	Pressure systems outside the scope of B31.3 as defined in this paragraph are unlikely to have B31.3 as part of the design basis.
A300.2 Definitions	This equivalency is not applicable to Category M Fluid Service, Elevated Temperature Fluid Service, High Pressure Fluid Service, or High Purity Fluid Service.

Design	
A301.1 Qualifications of the Designer	See above 300 General Statements (b) Responsibilities
A301.3 Design Temperature	This paragraph does not apply if the pressure system is in a relatively constant temperature environment (+/- 10°F) and the temperature is less than 120°F (50°C)

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	<i>NOTE: This is to ensure there is no effect from thermal linear change.</i>
A301.3.1 Design Minimum Temperature	<p>Category Normal: Minimum design temperature is a function of the material and the lower allowable temperatures in Table B-1.</p> <p>Category D: Lowest allowable minimum design temperature is -20°F (-29°C).</p>
A301.4 Ambient Effects	Does not apply if the pressure system is in a relatively constant temperature environment (+/- 10°F) and the ambient temperature is less than 120°F (50°C) (this is to ensure there is no effect from thermal linear change).
A301.5 Dynamic Effects	Impact, wind, earthquake, vibration, discharge reactions are required to be evaluated and discounted or applied.
A301.6 Weight Effects	Live and dead loads are required to be evaluated and discounted or applied.
A301.7 Thermal Expansion and Contraction Effects	<p>Paragraph normally does not apply to pressure system is in a relatively constant temperature environment (+/- 10°F) and the temperature is less than 120°F (50°C)</p> <p><i>NOTE: This is to ensure there is no effect from thermal linear change.</i></p> <p>This paragraph applies to pressure systems with appreciable thermal expansion or phase change induced volumetric expansion (increases of specific volume).</p>
A301.8 Effects of Support, Anchor, and Terminal Movements	This paragraph does not apply for flex hoses restraints to reduce whip hazard.
A301.9 Reduced Ductility Effects	Not applicable.
A301.10 Cyclic Effects	Not applicable.
A301.11 Air Condensation Effects	<p>Category Normal: Required to be evaluated and discounted or applied.</p> <p>Category D: Not applicable.</p>
A302.2.1 Listed Components Having Established Ratings	<p>Listed components shall be the first design preference.</p> <p>Previously evaluated and approved B31.3 unlisted components are located in the file Allowed Unlisted Components Microsoft Excel file.</p> <p>Unlisted components not on the list described above may be used if they are listed on the ESM Ch. 17 Reputable Manufacturers List. This list will be maintained on the ESM Ch. 17 website.</p>

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	<p><i>NOTE: Institutional Evaluation Suppliers List (IESL) is not necessarily a listing of reputable manufacturers.</i></p> <p>Commercial Grade Designation (CGD) qualifies ML-3 & 4 equipment from non-IESL suppliers for use in ML-1 & 2 service but does not qualify equipment for ASME B31.3 code equivalency to code concerns.</p>
A302.2.2 Listed Components Not Having Specific Ratings	Use reputable manufacturers' published ratings. A Reputable Manufacturers List of approved unlisted components will be maintained on the ESM Ch. 17 website.
A302.2.3 Unlisted Components	Use reputable manufacturers' published ratings. A Reputable Manufacturers List of approved unlisted components will be maintained on the ESM Ch. 17 website.
A302.2.4 Allowances for Pressure and Temperature Variations	Required to be evaluated and discounted or applied.
A302.3 Allowable Stresses and Other Stress Limits	Per design may consider other protective measures in order of precedence as follows: engineering controls (barriers, interlocks or controls), procedural controls (access control), and/or personal protective equipment (PPE).
A302.4 Allowances	Fluid will be evaluated and determined to be compatible for the service life of the system with the materials of construction and manufacturer's recommendations. or allowances must be added in accordance with the paragraph.
A304 Pressure Design of Components A304.1 Straight Pipe	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A304.1. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table B1 (unlisted material). (If using reputable manufacturer's published ratings this Part 2 does not apply.)</p> <p>Otherwise, protect personnel using other controls; engineering, administrative, and/or PPE as approved by the PSO.</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>

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<p>A304.2 Curved and Mitered Segments of Pipe</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A304.2. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table B1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>
<p>A304.3 Branch Connections</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A304.3. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table B1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>
<p>A304.3.1 General</p>	<p>Required to be evaluated and discounted or applied.</p>
<p>A304.3.2 Branch Connections Using Fittings</p>	<p>Required to be evaluated and discounted or applied.</p>
<p>A304.3.3 Additional Design Considerations</p>	<p>Required to be evaluated and discounted or applied.</p>
<p>A304.4 Closures</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A304.4. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table B1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>
<p>A304.5 Pressure Design of Nonmetallic Flanges and Blanks</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A304.5. The material shall meet 323.1 and must have a 3:1 factor of safety for materials not listed Table A1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>

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<p>A304.6 Reducers</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A304.6. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table B1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>
<p>A304.7 Pressure Design of Other Components</p>	<p>Initial design consistent with the design criteria of ASME B31.3 shall be a hoop stress evaluation at the minimum wall thickness at the maximum part diameter (worst case hoop stress) showing the design meets or exceed the stress. Note use B31.3 allowable stress values with B31.3 equations.</p> <p>Substantiation of the above may be done by one of the four items below:</p> <p><i>NOTE: System design pressure may be used to evaluate the component as the design pressure</i></p> <ol style="list-style-type: none"> 1) For a simple part that has no stress intensification factors (notches, threads, pits, cracks, etc.) the minimum calculated hoop stress shall be 4x the design pressure (MAWP). 2) Determine if the piping component was previously used in accordance with paragraph A304.7.2 (a). 3) Pressure test to 4x the design pressure (at maximum design temperature). 4) Perform Engineering Finite Element Analysis (FEA) in accordance with paragraph 304.7.2 (d).
<p>A305 Pipe</p>	<p>Paragraph is required to be evaluated and discounted or applied.</p>
<p>A306 Fittings, Bends, Miters, Laps, and Branch Connections</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A306. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table A1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>
<p>A307 Valves and Specialty Components</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A307. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table A1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>

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<p>A308 Flanges, Blanks, Flange Facings, and Gaskets</p>	<p>All LANL component designs or custom component designs for LANL shall comply with paragraph A308. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table A1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>
<p>A309 Bolting</p>	<p>If LANL is designing or having a design for a pressure component, the design shall comply with paragraph A309. The material shall meet A323.1 and must have a 3:1 factor of safety for materials not listed Table A1 (unlisted material).</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply.</i></p>
<p>A311 Bonded Joints in Plastics</p>	<p>Bonded plastic joints shall be done in accordance with ESM Chapter 13 <i>Welding, Joining, and NDE</i>.</p> <p>Follow manufacturer instructions for assembly of PCV solvent welded joints.</p>
<p>A311.2.3 Joints Limited to Category D Fluid Service</p>	<p>Applies only to Category D.</p>
<p>A318 Special Joints</p>	<p>Evaluate in accordance with A304.7 in this equivalency evaluation.</p> <p><i>NOTE: The use of "gland" in this paragraph does not mean Swagelok gland fitting.</i></p>
<p>A319 Flexibility of Nonmetallic Piping</p>	<p>Follow ESM Ch. 17 PS-REQUIREMENTS "Flexibility Analysis."</p>
<p>A320 Analysis of Sustained Loads</p>	<p>Piping is not to be used to support external equipment that is not part of the piping system.</p> <p>Paragraph is required to be evaluated and discounted or applied.</p> <p>Piping supports may be in accordance with LANL Master Specification 22 0529.</p> <p>If additional support is required see 321.</p>
<p>A321 Piping Supports</p>	<p>Use B31.3 paragraph as written in 321.1.2 "simple calculations and engineering judgment."</p>

Materials																	
A323 General Requirements	<p>Use listed materials:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Acrylonitrile-butadiene-styrene plastics</td> <td style="padding: 2px;">ABS</td> </tr> <tr> <td style="padding: 2px;">Chlorinated poly (vinyl chloride)</td> <td style="padding: 2px;">CPVC</td> </tr> <tr> <td style="padding: 2px;">Perfluoro (alkoxyalkane)</td> <td style="padding: 2px;">PFA</td> </tr> <tr> <td style="padding: 2px;">Polypropylene</td> <td style="padding: 2px;">PP</td> </tr> <tr> <td style="padding: 2px;">Poly (vinyl chloride)</td> <td style="padding: 2px;">PVC</td> </tr> <tr> <td style="padding: 2px;">Poly (vinylidene chloride)</td> <td style="padding: 2px;">PVDC</td> </tr> <tr> <td style="padding: 2px;">Poly (vinylidene fluoride)</td> <td style="padding: 2px;">PVDF</td> </tr> <tr> <td style="padding: 2px;">Polytetrafluoroethylene</td> <td style="padding: 2px;">PTFE</td> </tr> </table> <p>Additional listed materials are in B31.3 Appendix B. This evaluation does not apply to Test Articles.</p>	Acrylonitrile-butadiene-styrene plastics	ABS	Chlorinated poly (vinyl chloride)	CPVC	Perfluoro (alkoxyalkane)	PFA	Polypropylene	PP	Poly (vinyl chloride)	PVC	Poly (vinylidene chloride)	PVDC	Poly (vinylidene fluoride)	PVDF	Polytetrafluoroethylene	PTFE
Acrylonitrile-butadiene-styrene plastics	ABS																
Chlorinated poly (vinyl chloride)	CPVC																
Perfluoro (alkoxyalkane)	PFA																
Polypropylene	PP																
Poly (vinyl chloride)	PVC																
Poly (vinylidene chloride)	PVDC																
Poly (vinylidene fluoride)	PVDF																
Polytetrafluoroethylene	PTFE																
A323.1.2 Unlisted Materials	<p>Prior to using an unlisted material, the chemistry, physical and mechanical properties, method and process of manufacture, heat treatment, and quality control must be known as required by A323.1.</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply. The Designer is cautioned that materials must be suitable for the application and must be evaluated in accordance with A323.1 if necessary to determine the suitability of the material.</i></p>																
A323.1.3 Unknown Materials	<p>Unknown materials shall not be used.</p>																
A323.2 Temperature Limitations	<p>Category Normal: Use B31.3 paragraph as written.</p> <p>Category D: The minimum [−29°C (−20°F)] and maximum temperature as shown in the definition of Category D Fluid Service does not necessarily apply and must be verified as required by A323.2.</p>																
A323.2.1 Upper Temperature Limits, Listed Materials	<p>Materials shall have test results or manufacturers supplied data at or above the highest expected service temperature.</p>																

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<p>A323.2.2 Lower Temperature Limits, Listed Materials</p>	<p>Materials shall have test results or manufacturers supplied data at or below the lowest expected service temperature.</p> <p><i>NOTE: Non-metallic materials exhibit a "glass transition temperature" where the material becomes hard and may be susceptible to brittle fracture.</i></p>
<p>A323.2.3 Temperature Limits, Unlisted Materials</p>	<p>Use B31.3 paragraph as written to verify the temperature limits of the unlisted material meet the requirements of the design temperature.</p> <p><i>NOTE: This paragraph is for designing pipe and components, not for procurement of items offered for sale. If using reputable manufacturer's published ratings this paragraph does not apply. The Designer is cautioned that materials must be suitable for the temperature and must be evaluated in accordance with 323.2.3 if necessary to determine the suitability of the material.</i></p>
<p>A323.5 Deterioration of Materials in Service</p>	<p>Designer is required to design the pressure system for the service life of the system and consider material compatibility.</p>
<p>A326 Dimensions and Ratings of Components</p>	<p>Listed components shall be the first design preference.</p> <p>Previously evaluated and approved B31.3 unlisted components are in the Allowed Unlisted Components file.</p> <p>Unlisted components not on the list described above may be used if they are listed on the ESM Ch. 17 Reputable Manufacturers List. This list will be maintained on the ESM Ch 17 website.</p> <p>Listing on a reputable manufacturer's list requires ratings that are acceptable for the design conditions of temperature, pressure, and material compatibility.</p> <p>or</p> <p>Engineering calculations showing a factor of safety of 3:1 (this item would then be entered onto the reputable manufacturer's list as well). Items being placed on this list need final approval by the chief pressure safety officer (CPSO) or Designee.</p> <p>Commercial Grade Dedication (CGD) qualifies ML-3 & 4 equipment from non-IESL suppliers for use in ML-1 & 2 service but does not qualify equipment for ASME B31.9 code equivalency to code concerns.</p>
<p>Fabrication, Assembly, and Erection</p>	
<p>A328 Bonding of Plastics</p>	<p>Not required for low-risk pressure systems (FS3 or FS3-ULH as defined by P101-34, <i>Pressure Safety</i>).</p>
<p>A335 Assembly and Erection</p>	<p>Assemble in accordance with the manufacturer's requirements.</p>

<p>A340 Inspection A340.1 General</p>	<p>Qualified PSO Duty Area B may act as the Owner’s Inspector. Owner’s Inspector shall be knowledgeable with the pressure system of interest.</p>
<p>340.4 Qualifications of the Owner’s Inspector</p>	<p>See paragraph 300; Qualified PSO Duty Area B may act as the Owner’s Inspector or equivalent.</p>
<p>A345 Testing</p>	<p>Precautions in Appendix F, para. FA323.4 Material Considerations — Nonmetals should be considered. Pneumatic leak testing is approved for all systems with less than 1000 lb-ft stored energy during testing. Pressure systems with additional stored energy must be approved by the CPSO. Materials subject to brittle failure shall not be pneumatically tested. See A345 for other requirements for example test pressures (A345.4.2), test limitations (A345.2.1), and other requirements for pneumatic testing (A345.5.2) <i>NOTE: Be aware of the ramifications of using high molecular weight gases to test system for lower molecular weight gas. The engineering best practice is to use a lower or equal weight molecular weight gas as the referee test gas except for hydrogen where helium is accepted.</i> Category Normal: The Owner accepts pneumatic or hydro-pneumatic leak testing with inert gas or air (additional testing may be required by the Designer). Category D: Owner has elected to use Initial Service Leak Test for Category D Fluid Service (additional testing may be required by the Designer).</p>

3.0 RISK-BASED ENGINEERING EVALUATION PROCESS

This Risk-Based Evaluation process is used Section 2.0 above and may be used in other situations (e.g., ASME, NASME) where allowed by those sections or with a variance (Form 2137). This process is based on the methodology described in API Recommended Practice 580, *Risk-Based Inspection*.

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

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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 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.
 - 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).

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- 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 1-4).
 3. The Qualitative Risk based evaluation shall be based on probability and consequence of a single-point system failure for each deficiency observed.

Table 1-1 Probability factors to be considered

<ul style="list-style-type: none"> 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) <ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> 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 <ul style="list-style-type: none"> 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
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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
 - 1) 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 1-2, Failure Probability.
 2. Based on the results of the consequence evaluation, a consequence bin is selected as defined in Table 1-3, Consequence of Failure.
 3. Enter Table 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).
- All ASME B31.3 code equivalencies in this document shall have a QR number of 4 or higher.

Table 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 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 1-4 Qualitative Risk (QR) Determination

C o n s e q u e n c e			Probability				
			A	B	C	D	E
			Frequent	Probable	Occasional	Remote	Improbable
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	