

TABLE OF CONTENTS

D20 PLUMBING/PIPING/VESSELS

D20GEN GENERAL (R&D, Programmatic, and Facility) 3

1.0 Codes and Standards 3

2.0 Cross Connection Control 3

3.0 Expansion Control 5

4.0 Freeze Protection 6

5.0 Inspection 6

D2010 PLUMBING FIXTURES 7

1.0 General 7

2.0 Emergency Eyewash/Shower Equipment..... 7

D2020 POTABLE WATER..... 8

1.0 General 8

2.0 Disinfecting 9

D2030 SANITARY WASTE 9

1.0 General 9

D2040 STORM WATER 10

1.0 General 10

D2090 OTHER PLUMBING AND PIPING SYSTEMS (R&D, Prog, & Fac)..... 10

1.0 General 10

2.0 Compressed Air including Breathing Air..... 15

3.0 Natural Gas..... 18

4.0 Non-Potable Water 19

5.0 Radioactive Service General Guidance 20

6.0 Radioactive Liquid Waste 21

7.0 Process Liquid Waste 21

8.0 Vacuum 22

RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	6/28/99	Document rewritten and reformatted to support LIR 220-03-01. Superseded Mechanical Facilities Engineering Standards, Volume 6, Revision No. 15, dated 6/26/98.	Danny Nguyen, <i>PM-2</i>	Dennis McLain, <i>FWO-FE</i>
1	05/22/02	Changed FEM to LEM. General revision and addition of endnotes. Replaces subsections 203.2-.3, 203.6, 203.8-.12, and 204.29. D2010 is new.	Tobin H. Oruch, <i>FWO-SEM</i>	Kurt Beckman, <i>FWO-SEM</i>
2	6/9/04	Added relief valve documentation requirements. Added code, cross connect, exp control, freeze prot, and pressure systems/piping requirements formerly in D10-30GEN; Att 1 Inspection Checklist new. ASME B31.3 Guide became App A.	Charles DuPrè, <i>FWO-DECS</i>	Gurinder Grewal, <i>FWO-DO</i>
3	10/27/06	Administrative changes only. Organization and contract reference updates from LANS transition. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Master Spec number/title updates.	Charles DuPrè, <i>FM&E-DES</i>	Gurinder Grewal, <i>CENG</i>
4	9/29/09	Pressure safety material replaced by ESM Chapter 17. Metering requirements expanded.	Charles DuPrè, <i>ES-DE</i>	Larry Goen, <i>CENG</i>
5	9/29/14	General admin update, alignment to Chapter 17; minor changes to eyewashes, breathing air.	Michael Ladach, <i>ES-EPD</i>	Mel Burnett, <i>CENG</i>
6	2/26/15	Clarifications to freeze protection in 4.0.	Michael Ladach, <i>ES-EPD</i>	Mel Burnett, <i>CENG</i>

CONTACT THE MECHANICAL STANDARDS POC
for upkeep, interpretation, and variance issues

Ch. 6, D20	<u>Mechanical POC and Committee</u>
-------------------	---

This document is online at <http://engstandards.lanl.gov/>

D20 PLUMBING/PIPING/VESSELS

D20GEN GENERAL (R&D, PROGRAMMATIC, AND FACILITY)

1.0 CODES AND STANDARDS

- A. Pressure vessels and boilers shall be constructed to ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, except as noted in ESM Chapter 17, Pressure Safety.
- B. Piping and other vessels shall be installed to the governing codes and LANL Master Specifications. Governing Codes include:
 - 1. IAPMO/ANSI Uniform Mechanical and Plumbing Codes (UMC and UPC; edition per ESM Chapter 16 Section IBC-GEN App A - LEBC) when outside the scope of ESM Chapter 17.

2.0 CROSS CONNECTION CONTROL

2.1 General

- A. Comply with the UPC and AWWA M14, "Recommended Practice for Backflow Prevention Criterion," for cross connection control from non-potable sources or substances including, but not limited to, HVAC water systems, lawn sprinklers, fire protection systems, potable water outlets with hose fittings, etc., unless otherwise noted.
- B. Provide devices or assemblies installed for the prevention of backflow that have been approved and listed in the latest edition of Approved Backflow Prevention Assemblies by the University of Southern California Foundation for Cross Connection Control and Hydraulic Research.¹
- C. Separate non-potable water from potable water with a reduced-pressure-principle (RPP) backflow preventer (BFP) installed downstream of the building BFP.²
 - 1. Design non-potable water systems to minimize the number of BFPs.
 - 2. Provide cross-connection control between HVAC makeup and wet lab sinks to protect lab water purity.
- D. Locate building and fire protection BFPs inside the building to prevent freezing and facilitate maintenance (ESM Civil POC must approve outside installations in heated enclosures [e.g., "Hot Boxes"]).³
 - 1. For inside installations, provide a floor drain, connected to the sanitary sewer, near the BFP, sized to handle a full-open condition. Do not install BFPs in areas without reliable drainage.

¹ <http://www.usc.edu/dept/fccchr/list/>

² IAPMO/ANSI UPC-1-2009, Section 602.2

³ IAPMO/ANSI UPC-1-2009, Section 603.3.8

- E. A LANL Utilities & Infrastructure Group water system representative shall approve designs, submittals, and installation of BFPs installed in the site water distribution system outside the building wall.⁴
 - 1. Locate site BFPs above ground in heated enclosures (e.g., “Hot Boxes”) set on concrete pads and protect units from freezing.
- F. Provide parallel BFPs if building water supply cannot be interrupted in critical systems.
- G. Refer to the following LANL standards for additional requirements:⁵
 - 1. ESM [Civil](#) Chapter for site water distribution and site BFP.
 - 2. [Master Specifications](#) for fire protection sprinklers in Division 21 for fire riser BFP.
 - 3. [Master Specification](#) 22 1100, Facility Water Distribution [building BFP]
 - 4. [Fire Protection Drawing\(s\)](#) ST-D4010-1, Fire Sprinkler Risers [with BFP].
 - 5. [Mechanical Drawing\(s\)](#) ST-D10-30GEN-1, Site/Building Water Component Diagram.
 - 6. [Mechanical Drawing\(s\)](#) ST-D2020-2, Pressure Reducing Valve.

2.2 Permanent Buildings

- A. Provide an RPP-BFP in the potable water service line for each permanent building.⁶

2.3 Temporary Office Buildings⁷

- A. Provide a pressure-reducing valve (PRV) with a check valve in the potable water service line to each temporary office building (trailer, transportable, etc.).⁶
- B. Refer to Mechanical [Standard Drawing](#), ST-D2020-2, Sheet 2, for PRV detail.

2.4 Temporary Buildings with Chemical or Radiological Labs/Materials

- A. Provide an RPP-BFP in the potable water service line for each temporary building (trailer, transportable, etc.) with a chemical or radiological laboratory.
- B. If chemical (with the exception of janitorial chemicals) or radiological material is used and stored (no labs) in a temporary building, consult with a LANL Water Quality Group representative to determine if a RPP-BFP is required.

⁴ LANL Utilities and Infrastructure Group is responsible for the site distribution system.

⁵ The drawings and specifications provide piping details, additional design requirements, and backflow preventer specifications.

⁶ Original requirement from LANL Administrative Requirement AR 9-3, August 30, 1991 (EMref-2). Water Quality rescinded AR-9-3 and asked that the requirements be included into this chapter and the O&M Manual. RPP BFPs protect against all hazards per IAPMO UPC 1-2009, Table 6.2.

⁷ Defined in ESM Ch. 16 IBC-GEN

2.5 Fire Protection Systems ⁸

- A. Provide an RPP-BFP in a new fire system sprinkler riser when the fire protection system is supplied from a potable water system. Retrofitting existing systems is not required.
- B. Provide an RPP-BFP upstream of antifreeze loop(s) when a backflow preventer is not installed in the sprinkler riser supplied from a potable water system. Retrofitting existing antifreeze loops is required.
- C. Fire protection systems supplied from a dedicated fire loop or tank (non-potable water) do not require backflow protection.
- D. A LANL Fire Protection Group representative shall determine if parallel BFPs are required in the fire line.
- E. A LANL Fire Protection Group representative shall approve designs, submittals, and installation of BFPs installed in the fire line.

2.6 Landscape Irrigation and Lawn Sprinklers

- A. Provide an RPP-BFP in the potable water line supplying the irrigation system.
- B. Locate the backflow preventer outside above ground in a heated enclosure (“Hot Box”) set on a concrete pad or within the building in a heated space.

2.7 Heat Exchangers

- A. Heat exchangers used for heat transfer, heat recovery, or solar heating shall protect the potable water system from being contaminated by the heat transfer medium. Refer to UPC Section 603.4.4.

3.0 EXPANSION CONTROL

- A. Expansion Tanks:
 - 1. Any water system provided with a check valve, backflow preventer, or any other normally closed device that prevents dissipation of building pressure back into the water main shall be provided with an approved, listed, and adequately sized expansion tank or other approved device having a similar function to control thermal expansion. ⁹
 - 2. Provide ASME-coded expansion tank for systems designed to operate at or above 30 psig.
 - 3. *Size tanks per UMC, ASHRAE, or manufacturer’s recommendations.*
 - 4. Locate expansion tank on the suction (low pressure) side of the distribution pumping system to ensure proper operation.

⁸ IAPMO/ANSI UPC 1-2009, Section 603.4.16

⁹ UMC 2009 Section 608.3

5. *Guidance: Diaphragm (bladder type) tanks are recommended because they prevent air from entering the systems.*
6. *Guidance: Provide vertical models with floor stand when practical for space reasons.*

4.0 FREEZE PROTECTION¹⁰

- A. For closed aqueous systems exposed to freezing temperatures -- including and potable and non-potable water (including lawn sprinklers) -- provide freeze protection, such as heater cable or antifreeze, to prevent building and equipment damage when insulation alone will not prevent freezing due to insufficient water flow rate or still water.
 1. For fire sprinklers follow NFPA 13 and applicable Div 21 LANL Master Spec instead of this section.
- B. Antifreeze: If necessary, provide industrially inhibited propylene glycol (phosphate based) fluid manufactured by the Dow Chemical Company (Dowfrost) or approved equal, complying with ASTM D1384.
 1. Install in accordance with the manufacturer's instructions.
 2. Do not use automatic water make-up systems to prevent system contamination or system dilution. Provide an alarm in lieu of an automatic fill line to detect loss of antifreeze.
 3. *Guidance: Minimum mixture 50 percent glycol by volume will provide protection down to approximately minus 28 degrees F for still water.*
- C. Heat Tape: Specify self-regulating heater cable, hard-wired to a dedicated equipment protective device ground fault circuit. Provide a lockable (weatherproof, if outdoors) disconnect switch to facilitate lockout/tagout.¹¹
 1. Comply with requirements of NEC.
 2. Size and install heat tape in accordance with the manufacturer's instructions.
 3. Refer to LMS [22 0535](#), Electric Heat Tracing Systems, and [Mechanical Standard Drawing\(s\)](#) ST-D20GEN-2, Water Piping Freeze Protection.
 4. Label piping "Electric Traced" (refer to LANL Master Specification 22 0554, *Identification for Plumbing, HVAC, and Fire Piping and Equipment*).
 5. *Guidance: For critical facilities, a circuit continuity alarm may be required to detect loss of electrical power; see ESM Chapter 8.*

5.0 INSPECTION

- A. Comply with inspection requirements in applicable piping codes and LANL Master Specifications.

¹⁰ IAPMO/ANSI UPC 1-2009 UPC, Section 313.6

¹¹ The self-regulating effect allows the cable to be overlapped without creating hot spots or burnout. As the cable self-regulates its heat output, it provides for the efficient use of electric power, producing heat only when and where it is needed and also limiting the maximum sheath temperature.

D2010 PLUMBING FIXTURES

1.0 GENERAL

- A. Provide water-conserving fixtures in accordance with the UPC.¹²
- B. Provide toilet room fixtures, lavatories, urinals, and water closets, with ADA-compliant infrared sensors for automatic no-hands operation.¹³
 - 1. Provide water closet flushometer with override button.
- C. Fixture counts shall be per the UPC unless specifically changed by Architectural Chapter (in Section C-C1030).
- D. *Guidance: Provide sinks (kitchen, janitor closets, laboratories, etc.) with gooseneck type faucets to facilitate handling large containers.*
- E. Refer to LANL Master Specification 22 4200, *Plumbing Fixtures*, for additional requirements.

2.0 EMERGENCY EYEWASH/SHOWER EQUIPMENT

- A. Comply with ISEA Z358.1 on Emergency Eyewash and Shower Equipment.
- B. Provide tepid water to emergency equipment except for existing systems.¹⁴
 - 1. Provide a prepackaged, fully engineered and tested, mixing valve assembly furnished and/or manufactured by the manufacturer of the emergency equipment. *Guidance: A comfortable delivered water temperature range (per ANSI Z358.1-2009, Appendix B) is 60-100 degrees F. Units should be designed to provide a minimum discharge temperature of 80 F. .*
- C. Drains are not required to be provided for eye washes, safety showers, or combination installations. They shall not be routed to sanitary drains, storm drains, or the radioactive liquid waste system. If installed, the drains should be routed to a holding tank capable of accepting a minimum full rated flow (not less than 20 GPM) for a single installation. Sampling of collected water will determine appropriate disposal path. Consult Industrial Safety and Hygiene Group for determining usage factor for multiple installations.
- D. Refer to the following LANL Standards for additional requirements:
 - 1. Decontamination showers for rad areas: Provide tepid water per above and drain to RLW (or intermediate holding if directed by LANL). See ESM Chapter 11, Rad Protection, for additional requirements.
 - 2. [Mechanical Drawing\(s\)](#) ST-D2010-1, Emergency Shower/Eye wash
 - 3. [LANL Master Specification](#) 22 4200, *Plumbing Fixtures*

¹² IAPMO/ANSI UPC-1-2009 UPC, Section 402.0.

¹³ Automatic no-hands fixtures conserve water, require less maintenance, and help to control the spread of infectious diseases.

¹⁴ ANSI/ISEA Z358.1-2004 requirements.

D2020 POTABLE WATER

1.0 GENERAL

- A. Provide cross connection control devices in the building potable water system. Refer to Cross Connection Control Subsection above.
- B. Correct gas water heater selection for altitude. Refer to Mechanical Section D30GEN, Altitude Correction Subsection.
- C. Provide a building water pressure-regulating valve (PRV) when static pressure is in excess of 80 psi.¹⁵
 - 1. *Guidance: A setpoint of less than 60 psig may result in insufficient commode flush water for proper sewer line sweep. A PRV may be required in the building supply line or supply lines to critical equipment if fluctuations in pressure cannot be tolerated.*
- D. Provide potable water to all plumbing fixtures, emergency safety showers, and eyewash units.¹⁶ For exceptions to plumbing fixtures located in laboratories, refer to Non-Potable Water subsection below.
- E. Provide potable hot water to lavatories and sinks serving office spaces.¹⁷
- F. Provide a recirculation pump in the hot water system when the developed length of piping from the heater to the fixture exceeds 100 feet. Set the aquastat at 95 degrees F to control the pump. *Guidance: In installations where the hot water use is fairly continuous, eliminate the thermostat and run the pump continuously. In either case, consider including a timeclock to save energy during off-hours.*¹⁸
- G. *Guidance: Point-of-use electric tankless heaters are not recommended except for emergency applications (ex. eyewash and safety showers) where used infrequently.*¹⁹
- H. Building water meters are typically required. Refer to Mechanical Section D10-30GEN, Meters subsection.
- I. Refer to the following LANL standards for additional requirements:²⁰
 - 1. [Mechanical Drawing\(s\)](#) ST-D2020-1, Site/Building Water Component Diagram
 - 2. [Standard Detail](#) ST-D2020-2, Water PRV Piping Detail

¹⁵ IAPMO/ANSI UPC-1-2009 UPC, Section 608.2.

¹⁶ IAPMO/ANSI UPC-1-2009 UPC, Section 601.1.

¹⁷ LANL requirement for comfort. The UPC does not require hot water to be connected to sinks and lavs serving office spaces.

¹⁸ American Society of Plumbing Engineers (ASPE) Data Book, 1983-84, Pages 4-5, Supply Piping System (EMref-6). (*Note: EMref refers to a ESM team system for managing hard-to-find reference hardcopies.*)

¹⁹ LANL water is high in silica and eventually scale deposit will reduce the efficiency of the heating element, and the unit or heating element will have to be replaced. Safety equipment use is infrequent so tankless saves energy over having a large tank, but payback must be calculated.

²⁰ The drawings and/or specifications provide acceptable piping installation details, material specifications, and additional design criteria.

3. [Master Specification](#) 22 1100, *Facility Water Distribution*
4. Master Specification 22 3700, *Domestic Water Heaters*
5. ESM [Civil Chapter](#) for site water distribution system.

2.0 DISINFECTING

- A. Disinfect new or repaired potable water systems in accordance with LANL Master Specification 22 0816.²¹

D2030 SANITARY WASTE

1.0 GENERAL

- A. Connect discharge from soil, waste, and other drainage waste piping within the building (sanitary waste) to the building sewer outside the building wall. *Guidance: The sanitary sewer system delivers the discharge to the TA-46 sanitary wastewater system (SWWS) plant for treatment.*
- B. Only liquid waste meeting the sanitary liquid waste (SLW) waste acceptance criteria (WAC) shall be routed down drains connected to the building sanitary sewer.²² Internal: <http://int.lanl.gov/orgs/wdp/index.shtml>
- C. Minimize the number of floor drains in equipment rooms to prevent possible contamination (oil, etc.) transfer to the sanitary sewer system.
- D. Route drain piping from equipment close to walls or equipment to minimize a tripping hazard.
- E. For floor drains and similar trapped drains directly connected to the drainage system and subject to infrequent use, provide an automatic means of maintaining their water seal. The trap-priming device shall be accessible for maintenance.²³
- F. Refer to Mechanical Section D10-30GEN's "Water Discharged to the Environment and Sanitary Sewer" subsection for the LANL Water Quality Group requirements when discharging water from cooling towers, equipment blowdowns, hydrostatic testing, line disinfecting, etc., into the sanitary sewer.
- G. Group vent pipes to minimize roof penetrations. Size and locate vents per the UPC.
- H. Comply with the following LANL Standards:²⁴
 1. [Master Specification](#) 22 1316, *Sanitary Waste and Vent Piping*

²¹ IAPMO UPC 2009, Section 609.9. The specification provides disinfection and testing requirements and was written by the LANL Water Quality Group.

²² Supports LEED

²³ 2009 IAPMO/ANSI UPC 1-2009, Section 1007.0.

²⁴ The drawings and/or specifications provide acceptable piping installation details, material specifications, and additional design criteria.

2. Master Specification 22 1343.16, *Facility Wet-Well Packaged Sewage Pumping Stations (Interior)*
3. ESM [Civil Chapter](#) for site sanitary sewer system.

D2040 STORM WATER

1.0 GENERAL

- A. Design roof drain system for a 2.25 inches rainfall in a 1-hour period.²⁵
- B. Discharge primary and secondary roof drainage to the site storm sewer system. Do not connect to the building sanitary sewer system.²⁶
 1. When a storm sewer is not available, consult with representatives from the LANL Utilities & Infrastructure and Water Quality Groups.
- C. Locations where storm water will be discharged to grade must be reviewed for potential impacts to Solid Waste Management Units (SWMUs) and Potential Release Sites (PRSs). Consult with an EP Waste & Environmental Services Division representative.
- D. To prevent ice build-up, do not discharge storm water on the north side of the building near doors, sidewalks, etc. Route storm water away from the building and pedestrian walkways.
 1. *Guidance: Downspouts on the north side of the building should be located within the building and heat traced at the discharge to prevent ice build-up at the base of the downspout.*
- E. To prevent ground erosion, provide concrete splash blocks, river rocks, etc., under down spouts.
- F. Insulate storm water piping inside the building per LANL Master Specification 22 0713, Plumbing and HVAC Insulation.
- G. Refer to the following LANL Standards for additional requirements:²⁴
 1. [Master Specification](#) 22 1413, Facility Storm Drainage Piping.
 2. ESM [Civil](#) Chapter for site storm drainage system.

D2090 OTHER PLUMBING AND PIPING SYSTEMS (R&D, PROG, & FAC)

1.0 GENERAL

- A. When designing/specifying piping systems to the ASME B31 codes, identify the code of record by scope, then if necessary the fluid service category (D, normal, M, high pressure, and/or severe cyclic; use B31.3 Appendix M flowchart). These will drive the

²⁵ LANL Tech. Report No. LA 12195-MS, August 1992, Determination of 100 Year Floor Plain Elevations at LANL, Stephen G. McLin, Fig. 2 (EMref-7)

²⁶ IAPMO/ANSI UPC 1-2009, Sections 306.2 and 1101.2

inspection, examination, and testing required. *Use of the “cookbook” P-Specs (and Fluid Service Sheets when applicable) in ESM Chapter 17 REF-3, ASME B31.3 Process Piping Guide, is strongly preferred.*

- B. When designing or installing piping within the scope for the ASME B31 codes follow ESM Chapter 17.
- C. Consider the effects of erosion/corrosion, radiation, and thermal aging during the material selection process for all piping.²⁷
- D. *Guidance: Polymeric seals should not be used in radiological service where failure is unacceptable and expected lifetime radiation dose is greater than material damage threshold. The exception is installations where seal replacement can be performed regularly and cost-effectively, and administrative systems ensure such replacement.*²⁸
 - 1. *When maintaining polymers below damage thresholds cannot be assured, metal seals are recommended. Metal seals are also preferable where outgassing or leakage is detrimental, such as in radioactive or toxic gas and high vacuum systems.*
- E. *Guidance: When polymeric seal materials for valve stem tips, gaskets, and gland packing, pipe joints (gaskets), and thread lubricants/sealants are used in areas exposed to radiation, follow the guidance contained in [DOE Handbook 1132](#), Design Considerations, especially Section 11.5, Materials Considerations.*
- F. *Other Guidance:*
 - 1. *As can be seen in Table D10-30GEN-1 below, a general rule for elastomers used for sealing is that an accumulated radiation dose of 10^6 rads represents the point at which elastomers may be losing their ability to maintain a seal, particularly in a dynamic application where resiliency is required. Radioactive gas (e.g., tritium) that can diffuse into seal materials can accelerate damage rates.*
 - 2. *Materials containing polytetrafluoroethylene (PTFE) or trade name TeflonTM have significantly lower thresholds to radiation damage. A dosage of 1.7×10^4 rads causes substantial damage. Common trade and commercial names of PTFE-like materials include: Algoflon, Duroid, Fluon, Fluorocomp, Gortex, Halon TFE, Kalrez perfluoroelastomer, Kel-F polychlorotrifluoroethylene, Neoflon, Polycomp, Polyflon and Teflon.*
 - 3. *When radiation exposure can be adequately predicted and controlled below threshold damage levels, select a polymer based on expected environmental conditions including dose. Polymers with relatively higher radiation resistance include Vespel polyimide, Ultra-High-Molecular-Weight Polyethylene (UHMWPE), Ethylene Propylene Diene Monomer (EPDM), and PEEK (Polyetheretheracetone).*

²⁷ ASME B31.3, requirements

²⁸ DOE-STD-1132-99, Part II, Section 5

Table D10-30GEN-1
Relative Stability of Plastics

Material	Radiation Dosage for Threshold Damage (rad)	Radiation Dosage for 25% Damage (rad)
Polystyrene	8×10^8	4×10^9
Phenol formaldehyde (asbestos filler)	3.9×10^8	3.9×10^9
Polyester (mineral filler)	8.7×10^8	3.9×10^9
Polyvinyl Chloride	1.9×10^7	3.9×10^8
Polyethylene	1.9×10^7	9.3×10^7
Urea formaldehyde (unfilled)	8.3×10^6	5.1×10^7
Monochlorotrifluoro-ethylene	1.2×10^6	2×10^7
Cellulose acetate	2.7×10^6	1.9×10^7
Phenol formaldehyde (unfilled)	2.7×10^6	1.1×10^7
Methyl methacrylate	8.2×10^5	1.1×10^7
Polyester (unfilled)	3.4×10^5	8.7×10^5
Polytetrafluoroethylene (Teflon™)	1.7×10^4	3.7×10^4

Reference: Carroll, J.G., and Bolt, R.O., "Radiation effects on Organic Materials," *Nucleonics* Vol. 18, No. 9, September 1960, p.73.

G. Tube Bending²⁹

- When selecting tubing outside the scope of the UPC and UMC, design with accounting for pressure, erosion/corrosion, and ovality and wall thinning resulting from bending in the applicable ASME code. *Guidance: ASME B31.3 bending is addressed in ESM Chapter 17. Table D2090-2 can also be used to determine wall thinning for a given bend radius.*

²⁹ ASME B31.3

Table D2090-2³⁰

Wall Thinning when Bending Tubing			
	For Tube Bend $\leq 180^\circ$		
Tubing OD (inch)	Centerline Bend Radius (inch)	Centerline Calculated Bend Radius (diameters)	Wall Thinning (%)
1/8	5/16	2.5	17
1/4	9/16	2.25	18
1/4	5/8	2.5	17
1/4	3/4	3.0	14
5/16	25/32	2.5	17
5/16	15/16	3.0	14
3/8	15/16	2.5	17
1/2	1-1/4	2.5	17
1/2	1-1/2	3.0	14
5/8	1-9/16	2.5	17
3/4	1-7/8	2.5	17
1	2-1/2	2.5	17

H. Compression Fittings

1. When using Swagelok compression fittings, install per LANL Master Specification 40 0511, Compression Fittings on Copper and Stainless Steel Tubing.³¹
2. Installers of compression fittings shall be trained one-time by the manufacturer or an authorized distributor, or through a formal LANL course for the following applications:³²
 - safety significant (SS), safety class (SC), and vital safety systems (VSS)
 - nuclear/radiological (glove boxes, wash downs, CAMs, etc.)
 - toxic systems
 - intermediate and high pressure systems (defined here as 150 psi gas/1500 psi liquid and 3000 psi gas/5000 psi liquid max allowable operating pressures, respectively).

³⁰ FWO Calculation Number: 00-00-CALC-M-0002.

³¹ LANL Master Specification 40 0511 provides detailed instructions that ensure a leak-tight installation. The spec was thoroughly researched using both DOE (SRS, Y-12) and commercial nuclear (Duke) information sources. Material compatibility is required by the ASME piping series (e.g., B31.3, Process Piping). DOE HDBK-1132-99 contains the collected knowledge of the DOE complex on compatibility and piping design. Because the specification covers copper and stainless tubing only, modifications may be required for other materials and methods; such modification should only be performed by a trained and experienced engineer.

³² Corrective action for Type A Accident Investigation of the March 16, 2000 Plutonium-238 Multiple Intake Event at the Plutonium Facility Los Alamos National Laboratory New Mexico dated 7/2000 at; LANL Notice 51 response; concurrence of PS and FWO Div Leaders 3/31/04 [EMRef23]

3. Acceptable courses are addressed in LANL Master Specification 40 0511.
4. Ensure tubing and fitting materials are compatible with each other and the fluid service. Follow [DOE Handbook 1132](#), Design Considerations (especially Materials Considerations, *Section 11.5*)
5. *Guidance: Where leakage is unacceptable, maximize the use of welded or brazed joints and minimize mechanical joints by use of tube bending and well-considered arrangements. Compression fittings do not provide the same assurance of leak-tightness as welding; however, when properly installed per LANL Master Specification 40 0511, they provide an economical non-welded means to join tubing that can be made and remade a number of times.*
In applications where space is tight, frequent remakes are likely, or leak-tightness is essential (e.g., tritium and high vacuum systems), Cajon VCR fittings are generally preferred. For extreme pressures, coned-and-threaded high-pressure fittings made by PPI and Autoclave Engineers are available.
6. *Guidance: Use of compression fittings outside the scope of LANL Master Specification 40 0511 should be at the written direction of a technical person familiar with their application and use.*³³

I. Testing

1. Test piping systems in accordance with applicable codes.³⁴
 - a. Reference LANL Master Specification 22 0813, *Testing Piping Systems*, which may require changes for existing system modifications.³⁵
2. Hazardous and Nuclear Only: Design to facilitate decontamination and demolition; include:³⁶
 - a. Equipment, including effluent decontamination equipment, which precludes, to the extent practicable, the accumulation of radioactive or other hazardous materials in relatively inaccessible areas, including curves and turns in piping. Accessible, removable covers for inspection and cleanouts are encouraged.
 - b. Provisions for flushing and/or cleaning contaminated or potentially contaminated piping systems.
 - c. Piping systems that carry contaminated or potentially contaminated liquid that free drain via gravity where possible.

³³ LANL Master Specification 40 0511 provides detailed instructions that ensure a leak-tight installation. Its development followed a Type A Accident Investigation of the March 16, 2000 Plutonium-238 Multiple Intake Event at the Plutonium Facility Los Alamos National Laboratory New Mexico dated 7/2000. The spec was thoroughly researched using both DOE (SRS, Y-12) and commercial nuclear (Duke) information sources. Material compatibility is required by the ASME piping series (e.g., B31.3, Process Piping). DOE HDBK-1132-99 contains the collected knowledge of the DOE complex on compatibility and piping design. Because the specification covers copper and stainless tubing only, modifications may be required for other materials and methods - such modification should only be performed by a trained and experienced engineer.

³⁴ Piping tests are code requirements per the IAPMO/ANSI UPC 2009 and UMC 2009, and nationally recognized codes such as ASME B31.1, ASME B31.9, etc. The specification provides reporting and testing requirements for specific piping systems.

³⁵ Piping tests are code requirements per the IAPMO/ANSI UPC 2009 and UMC 2009, and nationally recognized codes such as ASME B31.1, ASME B31.9, etc. The specification provides reporting and testing requirements for specific piping systems.

³⁶ DOE G 420.1-1A Section 5.4.1

2.0 COMPRESSED AIR INCLUDING BREATHING AIR

2.1 General

- A. Determine free air delivery (FAD) cfm (actual volume flow rate of compressed air converted back to the inlet ambient conditions of the compressor) , remembering that altitude correction is required and that with a compressed air system there is a good possibility of sizable diversity in demand.
- B. Design piping to eliminate areas where water may accumulate, i.e., slope piping to oil/water separators, specify drain valves or traps at low points, etc.
- C. Provide an oil/water separator (torpedo) in drain piping from a lubricated compressor system that discharges into the sanitary sewer. Oil-less/oil-free compressor piping systems do not require an oil/water separator but do require an automatic drain valve. Refer to the compressed air piping drawings referenced below for details.³⁷
- D. Refer to the following LANL Standards for additional requirements:³⁸
 - 1. [Mechanical Drawing\(s\)](#) ST-D2090-1, Compressed Air Piping.
 - 2. [Master Specification](#) 22 1500, *Compressed Air Systems*.
- E. *Guidance: Generally accepted practice is to allow 10 percent of the proposed system pressure for pipe friction loss. When computing the total friction drop in the piping, the friction in the fittings and valves must be considered and the total equivalent length used. It is also considered good practice to oversize the distribution lines to allow for further growth and to allow for future addition of equipment that may add a pressure drop not anticipated at the time of original design*
- F. Breathing air supply system shall comply with the requirements of the Occupational Safety and Health Administration’s (OSHA) 29 CFR, Part 1910, Section 134.

2.2 Altitude Correction

- A. Derate the compressor free air delivered listed in the manufacturer’s catalog data for altitude and temperature. Refer to ESM Mechanical Section D30GEN, Altitude Correction Subsection.

2.3 Definitions (this subsection)

aftercooler	Heat exchanger (air or water) for cooling air discharged from compressor; provide effective means of removing moisture from compressed air.
approach temperature	The number of degrees above the temperature of the cooling medium (air or water) to which the aftercooler reduces the compressed air temperature.

³⁷ An oil/water separator is required in order for the liquid waste from the compressed air system to meet the sanitary liquid waste acceptance criteria

³⁸ The drawings and specification provide piping diagrams for different types of compressors (oil-less, tank mounted, etc.), component specifications, and additional design requirements.

free air delivery (FAD)	Actual volume flow rate of compressed air converted back to the inlet conditions (normally ambient standard air conditions).
dew point	The temperature at which condensate will begin to form if the air is cooled at a constant pressure. At this point, the relative humidity is 100 percent.
actual cfm (acfm)	Actual volume flow rate in the pipework after the compressor.
standard cfm (scfm)	Volume flow rate at standard air conditions (at a temperature of 68F, at a pressure of 14.5 psia, a relative humidity of 0%) ³⁸
instrument air	Refer to ISA 7.0.01, Quality Standard for Instrument Air (formerly ANSI/ISA S7.0.01), for the four elements (pressure dew point, particle size, lubricant content, and contaminants) of instrument air quality for use in pneumatic instruments.
oil-free	Generally applies to the condition of the air either when it leaves the compressor, or after filtration. An oil-free compressor will have no lubrication on the compression side of the machine. However this may not result in oil-free compressed air, simply due to the fact that the ambient air (or, for reciprocating compressors, crankcase oil being sucked past the rings) going into the compressor may contain hydrocarbons.
oil-less compressor	A compressor that has a complete absence of any lubricating fluids and produces oil-less compressed air. A small reciprocating compressor with PTFE piston rings and PTFE bearer rings, sealed for life bearings and no sump oil would be called an oil-less compressor.
Pressure dew point	The temperature at which water vapor will begin to condensate inside a pipeline at a given pressure.
torpedo	A LANL developed and patented oil/water separator.

2.4 System Components

- A. Aftercooler: Equip each compressor with an aftercooler sized to provide a 5 to 20 degrees F approach temperature. *Guidance: For most systems, use an air-cooled type aftercooler. For larger compressed air systems, it maybe more efficient to use a water-to-air heat exchanger with a chilled water or tower water source. Most rotary screws include an aftercooler as a standard feature. Means for automatic drainage (mechanical air/water separator) should be provided downstream of the aftercooler. Mechanical air/water separator traps are standard on most rotary screws and optional on reciprocating, tank-mounted compressor packages. If tank-mounted unit has an electric automatic drain valve, the mechanical air/water separator is optional.*
- B. Air Dryers: Use a refrigerated air dryer (35 – 38 degrees F pressure dew point) when the compressed air system ambient temperature is always 40 degrees F and above. For portions of system below 40 degrees F ambient temperature, use a regenerative air dryer (minus 40 degree F pressure dew point).³⁹ Note: Heatless regenerative air dryers consume 5 to 18 percent of compressed air capacity.

³⁹ Prevents condensate freeze-up

- C. Intake Air Piping: Take intake air from the cleanest possible location. Avoid air intakes from dirty locations within the building, and hot (greater than 100 degrees F) or humid locations.
- D. Air Intake Filter: Equip the compressor inlet with a filter to remove dirt from the air. *Guidance: An optional muffler/silencer should be considered if compressor noise is a problem.*
- E. Receiver: Equip each reciprocating air compressor with a receiver tank to dampen pulsations. Provide a receiver tank with a pressure gauge, safety relief valve, and drain valve, and an ASME code-stamped tank.
- F. Mechanical Air/Water Separator: Provide separators with the compressor package to remove water that has condensed in the aftercooler of the compressor.
- G. Sound Attenuation: For applications requiring low noise (below 85 dBa), specify a sound enclosure for a rotary screw compressor or intake filter/silencers and/or mufflers for reciprocating compressors. (Consult compressor manufacturer for availability).

2.5 Outdoor Installation

- A. To protect the unit from weather and freezing, equip the compressor with the following:
 - 1. TEFC motors and NEMA 4 controls, starters, and pressure switches.
 - 2. Heaters as recommended by manufacturer.
 - 3. Watertight intake filters.
 - 4. Heat-tape for air/water separators and any other condensate drain piping.

2.6 Compressed Air Quality Guidance⁴⁰

- A. As illustrated in Table D2090-3 below, a number of different air quality levels exist:

Table D2090-3

Quality	Likely Applications at LANL
Plant Air	Air tools, general use
Instrument Air	Climate control (damper actuators and pneumatic controls), lab use, paint spraying. <i>Should meet ISA 7.0.01, Quality Standard for Instrument Air. System recognized by ESM Chapter 1 Section 210.</i>
Process Air	Special processes sometimes requiring higher cleanliness
Breathing Air	Contamination Area supplied-air systems, <i>requirements per ESM Chapter 11, Radiation Protection. System recognized by ESM Ch 1 Section 210.</i>

- 1. **NOTE:** Standards do not exist for all levels above; when using these terms, actual specs for quality must be given.

⁴⁰ Advanced Management of Compressed Air Systems, c 1999, The Compressed Air Challenge

2. In addition to ISA and CGA standards above, ISO 8573 provides detailed standards on air quality classes for various levels of particulate, moisture, and lubricant contaminants. These are provided for reference only in Table D2090-4 below.

Table D2090-4

ISO 8573 Class	Max Oil Content g/m ³	Max Particle Size		Pressure Dewpoint	
		µm	mg/m ³	°C/°F	g/m ³
1	0.01	0.1	0.1	-70/-94	0.003
2	0.1	1	1	-40/-40	0.12
3	1	5	5	-20/-4	0.88
4	5	15	8	3/37	6
5	25	40	10	7/45	7.8
6	--	--	--	10/50	9.4
7	--	--	--	Not specified	
ISA 7.0.01-1996 (ref)	1 ppm	40, less if req'd	particle "free"	4/39 max and 10/18 deg below ambient	
Breathing Air CGA 7.1 Gr D (ref)	.005	None implied	None implied	No limit	

3.0 NATURAL GAS

- A. From the low pressure regulator to the appliance, supply 14 inches water column or less gas pressure to indoor equipment.⁴¹
- B. Gas meters are typically required. Refer to Mechanical Section D10-30GEN, Meters Subsection; and Civil Chapter (*Section G30*) for related requirements in either case.
- C. Locate gas pressure regulator vents and stacks so that gas is safely discharged into the atmosphere. Locate gas regulator not less than 10 feet horizontally from intake air devices, e.g., louvers, fans, doors, windows etc.⁴²
- D. Refer to the following LANL standards for additional requirements:
 1. [Civil Drawing\(s\)](#) ST-G3060-2, Gas Regulation Station.
 2. Master Specification 23 1123, *Facility Natural Gas Piping*.
 3. ESM [Civil Chapter](#) for site natural gas distribution system.
- E. Comply with the requirements of the UPC, UMC, and NFPA 54.
- F. Utility piping from the distribution system to the low pressure regulator shall be in accordance with ESM Chapters 3 and 17.

⁴¹ NFPA 54, 2012, Section 5.8.3

⁴² NEPA 54, 2012, Section 5.9.7.1. The 10-ft dimension is a LANL requirement.

4.0 NON-POTABLE WATER

- A. Separate non-potable water from potable water. Refer to D20GEN, Cross Connection Control article above.
- B. Provide non-potable cold water (and hot water when required) to fixtures (e.g., sinks, hose bibs) located in laboratories, except for restrooms located within the laboratory. The user will identify laboratory fixtures requiring hot water.⁴³
- C. Provide a recirculation pump in the hot water system when the developed length of piping from the heater to the fixture exceeds 100 feet. Set the aquastat at 95 degrees F to control the pump. *Guidance: In installations where the hot water use is fairly continuous, eliminate the thermostat and run the pump continuously. In either case, consider including a timeclock to save energy during off-hours.*⁴⁴
- D. *Guidance: Point of use electric tankless heaters are not recommended except for emergency applications where used infrequently.*⁴⁵
- E. Label each fixture served by non-potable water.⁴⁶
- F. Provide non-potable water for make-up to HVAC piping systems.⁴⁷
- G. Provide make-up line on the suction side of the pump with a pressure reducing valve, isolation valves, and 1-inch minimum quick fill line.
- H. Discharging water to the environment or sanitary sewer from a “once through” system (e.g., water-cooled equipment, water-seal vacuum pumps, etc.) is not permitted unless approved by the LANL Water Quality Group.⁴⁸
- I. Flush and chemically treat non-potable HVAC systems and flush non-potable water systems serving non-potable plumbing fixtures. Non-potable water systems do not require disinfecting.⁴⁹
- J. Refer to the following LANL standards for additional requirements:
 - 1. [Mechanical Drawing\(s\)](#) ST-D2020-1, Site/Building Water Component Diagram.

⁴³ IAPMO UPC 2009, Section 602

⁴⁴ American Society of Plumbing Engineers (ASPE) Data Book, 1983-84, pages 4-5, Supply Piping System (EMref 6).

⁴⁵ LANL water is high in silica and eventually scale deposit will reduce the efficiency of the heating element and the unit or heating element will have to be replaced.

⁴⁶ IAPMO UPC 2009, Section 601.2

⁴⁷ IAPMO UPC 2009, Sections 603.4.11 and 603.4.12

⁴⁸ Memo from Harvey Decker, (LANL Water Quality Group), dated 8/29/00, states: (EMref-5)

“Laboratory is aggressively pursuing a “zero” discharge status for all NPDES permitted outfalls (and all discharges in general). As part of this program waste minimization and water conservation are the main drivers. The LANL Water Quality Group has been working for several years to eliminate all “once through” type of equipment at the Laboratory. Additionally, especially in the area of water seal vacuum pumps, the Laboratory has experienced contamination of the discharged cooling water to the SWWS plant, which has or had the potential for NPDES Permit violations. These types of discharges to the SWWS plant may be considered for acceptance on a case by case basis but the SWWS WAC (Waste Profile Form Guidance, [P409](#) should be followed). Other information can be found at the Water Pollution Control [P407](#) and General Waste Management Requirements [P409](#), section 5.4.3.”

⁴⁹ Not a code requirement. IAPMO UPC 2009, Section 609.9

2. [Mechanical Drawing\(s\)](#) ST-D3030-1 and ST-D30GEN-1, (non-potable make-up piping to HVAC systems).
3. [Master Specification](#) 22 1100, *Facility Water Distribution*.
4. [Master Specification](#) 23 2113, *Hydronic Piping*.
5. [Master Specification](#) 23 2500, *HVAC Water Treatment*.
6. [ESM Civil Chapter](#) for site water distribution system.

5.0 RADIOACTIVE SERVICE GENERAL GUIDANCE

- A. *Follow the guidance contained in [DOE Handbook 1132](#), Design Considerations*
- B. *Guidance: Polymeric seals should not be used in radiological service where failure is unacceptable and expected lifetime radiation dose is greater than material damage threshold. The exception is installations where seal replacement can be performed regularly and cost-effectively, and administrative systems ensure such replacement*⁵⁰
 1. *When maintaining polymers below damage thresholds cannot be assured, metal seals are recommended. Metal seals are also preferable where outgassing or leakage is detrimental, such as in radioactive or toxic gas and high vacuum systems.*
- C. *Guidance: When polymeric seal materials for valve stem tips, gaskets, and gland packing, pipe joints (gaskets), and thread lubricants/sealants are used in areas exposed to radiation, see DOE Handbook 1132, Part II, Section 5, Materials Considerations.*
- D. *As can be seen in Table D2090-1 below, a general rule for elastomers used for sealing is that an accumulated radiation dose of 10^6 rads represents the point at which elastomers may be losing their ability to maintain a seal, particularly in a dynamic application where resiliency is required. Radioactive gas (e.g., tritium) that can diffuse into seal materials can accelerate damage rates.*
- E. *Materials containing polytetrafluoroethylene (PTFE) or trade name TeflonTM have significantly lower thresholds to radiation damage. A dosage of 1.7×10^4 rads causes substantial damage. Common trade and commercial names of PTFE-like materials include: Algoflon, Duroid, Fluon, Fluorocomp, Gortex, Halon TFE, Kalrez perfluoroelastomer, Kel-F polychlorotrifluoroethylene, Neoflon, Polycomp, Polyflon and Teflon.*
- F. *When radiation exposure can be adequately predicted and controlled below threshold damage levels, select a polymer based on expected environmental conditions including dose. Polymers with relatively higher radiation resistance include Vespel polyimide, Ultra-High-Molecular-Weight Polyethylene (UHMWPE), Ethylene Propylene Diene Monomer (EPDM), and PEEK (Polyetheretheracetone).*

⁵⁰ DOE-STD-1132-99; FWO-MSE Course EDS 212416, "Teflon Sealing Material Selection and Maintenance," 12/2000, W. Radzinski; and Type A Accident Investigation of the March 16, 2000 Plutonium-238 Multiple Intake Event at the Plutonium Facility Los Alamos National Laboratory New Mexico dated 7/2000, LANL Notice 51 response.

Table D2090-1
Relative Stability of Plastics

Material	Radiation Dosage for Threshold Damage (rad)	Radiation Dosage for 25% Damage (rad)
Polystyrene	8×10^8	4×10^9
Phenol formaldehyde (asbestos filler)	3.9×10^8	3.9×10^9
Polyester (mineral filler)	8.7×10^8	3.9×10^9
Polyvinyl Chloride	1.9×10^7	3.9×10^8
Polyethylene	1.9×10^7	9.3×10^7
Urea formaldehyde (unfilled)	8.3×10^6	5.1×10^7
Monochlorotrifluoro-ethylene	1.2×10^6	2×10^7
Cellulose acetate	2.7×10^6	1.9×10^7
Phenol formaldehyde (unfilled)	2.7×10^6	1.1×10^7
Methyl methacrylate	8.2×10^5	1.1×10^7
Polyester (unfilled)	3.4×10^5	8.7×10^5
Polytetrafluoroethylene (Teflon™)	1.7×10^4	3.7×10^4

Reference: Carroll, J.G., and Bolt, R.O., "Radiation effects on Organic Materials," *Nucleonics* Vol. 18, No. 9, September 1960, p.73.

6.0 RADIOACTIVE LIQUID WASTE

- A. Only liquid waste meeting the radioactive liquid waste (RLW) waste acceptance criteria (WAC) shall be routed down drains connected to the Radioactive Liquid Waste Treatment Facilities (RLWTF) at TA-50 and TA-53.
- B. Refer to the WAC for the wastewater collection system acceptance requirements. See LANL [P409](#), *Waste Management*.
 1. Contact RLW for the RLW collection system requirements, e.g., acceptable waste criteria, collection system pipeline design, fixture and pipeline labeling, etc.
 2. Refer to Mechanical Section D10-30GEN, Mechanical and Plumbing Codes Subsection, for amendment to UMC, Chapter 14, Process Piping.
 3. If an RLW site collection system is not available, liquid waste meeting the RLW WAC shall be collected in appropriate containers or tanks. Contact RLW and ENV-RCRA Groups or the site waste management coordinator for collection and disposal requirements.
- C. See ESM Chapter 17 for required ASME B31.3 Fluid Service category (*Normal*).

7.0 PROCESS LIQUID WASTE

- A. Process liquid waste, either hazardous or non-hazardous, but **not** meeting the sanitary liquid waste (SLW) WAC or the RLW WAC shall be collected in appropriate containers

or tanks. Contact ENV Solid Waste Regulatory Compliance Group, or the site waste management coordinator for regulatory requirements -- e.g., collection, disposal, fixture/piping labeling, etc.

8.0 VACUUM

See ESM Chapter 17 for vacuum system requirements.