6.4 Mechanical, Electrical, and Plumbing Components

6.4.5 Fluid Piping, not Fire Protection

6.4.5.1 Hazardous Materials Piping

This category covers fluid piping, other than pressure piping or fire protection piping, that transfers fluids under pressure, by gravity, or that are open to the atmosphere. Specifically, the fluids in this category are hazardous and flammable liquids that would pose an immediate life safety danger due to their inherent properties. Hazardous materials and flammable liquids that would pose an immediate life safety danger if exposed are described in NFPA Standards such as NFPA 49, *Hazardous Chemicals Data*, and NFPA 491, *Hazardous Chemical Reactions,* as listed in the NFPA Fire Protection Guide to Hazardous Materials (NFPA, 2010).

Provisions

BUILDING CODE PROVISIONS

ASCE/SEI 7-10, *Minimum Design Loads for Buildings and other Structures*, (ASCE, 2010), requires the use of a component importance factor, I_p, of 1.5 if the component conveys, supports or contains toxic, highly toxic or explosive substances. The quantities of materials that trigger the requirements are established by the authority having jurisdiction and are based on a determination of the threat to the public if the material is released.

- The piping and supports may be designed using the provisions of ASME B31 *Process Piping* (ASME, 2008) or ASCE/SEI 7-10. If ASME B31 is used, the forces and displacements of ASCE/SEI 7-10 must be used for design.
- In addition to force and displacement design, special certification is required demonstrating that any component containing hazardous materials with an I_p of 1.5 will maintain containment under seismic loading. Thus any component covered by the above descriptions is a “designated seismic system” and, unless it falls under the exemption for mechanical and electrical components in Seismic Design Category B, requires engineering, special certification, or special inspection.

RETROFIT STANDARD PROVISIONS

ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*, (ASCE, 2007) classifies hazardous material piping systems as both acceleration and deformation sensitive.

- Hazardous material piping systems are subject to the requirements of ASCE/SEI 41-06 when
  - The performance level is Immediate Occupancy or Life Safety in high, moderate, and low seismicity areas.
  - The performance level is Hazards Reduced in high, moderate, and low seismicity areas and the system is close proximity to occupancy such that leakage could cause an immediate life safety threat.
- Acceptance criteria focus on performing drift analysis to determine if the glazing can accommodate the expected story drifts, and the anchorage of the panels under seismic loading. The evaluation approach is similar to that used in ASCE/SEI 7-10.
  - ASCE/SEI 41-06 requires compliance with the anchorage provisions of the standard when the performance level is Life Safety or higher.
  - Rehabilitation may utilize prescriptive standard.

Typical Causes of Damage

- . Vulnerable locations in hazardous fluid piping include joints, bends, connections to rigidly mounted equipment and risers subjected to significant relative movement between floors. These piping systems have failure modes common to all piping systems, but the consequences of failure are more severe.
- Fluids may leak from damaged joints or broken pipe. Hazardous and flammable fluid spills may result in fire, explosion, or evacuation to avoid personal exposure. The risk for injury, property losses and business outages is high.
- Damage to any part of the hazardous piping system may compromise its functionality and connected equipment or systems may be disabled due to piping leaks or failures. For example, many hazardous piping systems are designed with safety systems to reduce the likelihood of leakage such as secondary containment with double walled pipes, automatic shut-off or excess flow valves, leak detection systems, use of non-jointed piping and highly ductile pipe materials, etc. If not properly designed, installed and maintained, any of these secondary or backup systems could also be damaged resulting in hazardous material leaks or loss of functionality.

DAMAGE EXAMPLES

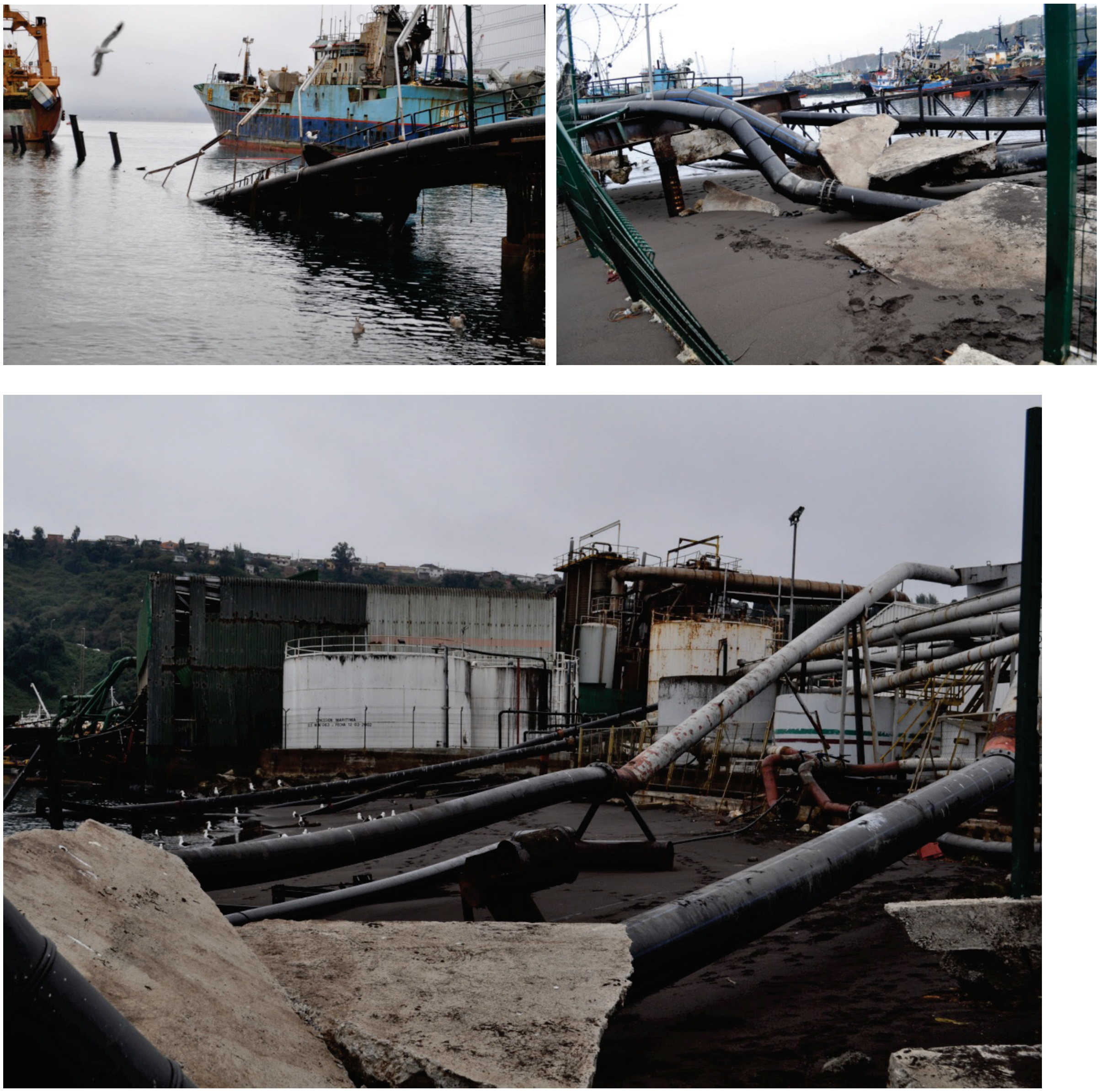


Figure 6.4.5.1-1 Earthquake, liquefaction, and tsunami damage to oil supply lines at the port in Talcahuano in the 2010 magnitude-8.8 Chile Earthquake. The pier in upper photo collapsed over much of its length dragging the pipes down into the water; this caused tension failures in some pipe joints and also resulted in structural damage to the buildings (Photos courtesy of Eduardo Fierro, BFP Engineers).

Figure 6.4.5.1-2 Basement level at power plant in Port-au-Prince flooded with oil and water in the 2010 magnitude-7 Haiti Earthquake creating hazardous conditions for inspection and clean-up (Photos courtesy of Eduardo Fierro, BFP Engineers).

Figure 6.4.5.1-3 Elephant foot damage to inadequately anchored fuel tank in the 2010 Chile Earthquake also resulted in damage to fuel lines. Close-up photo shows failed pipe at welded joint (left) and pipe segment with attached valve (foreground) tore out of the tank wall (Photos courtesy of Eduardo Fierro, BFP Engineers).

Seismic Mitigation Considerations

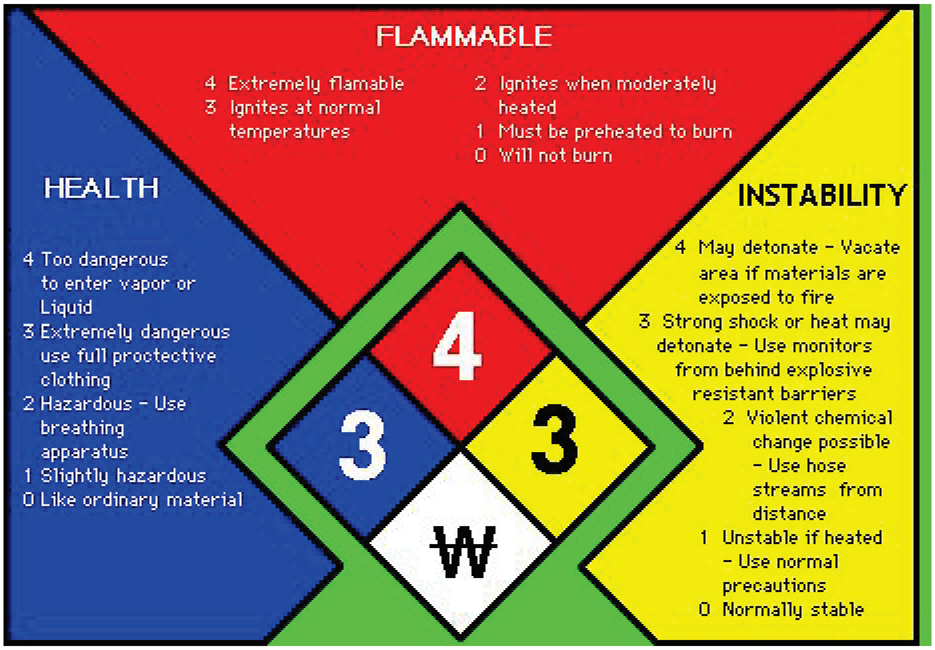
Fuel and natural gas lines are found in many common settings, but this category also covers more hazardous types of piping found in industrial facilities, power plants or hospitals. The national standard for pressure piping, ASME B31.3, *Process Piping* (ASME, 2008), defines hazardous fluid service as "a fluid service in which the potential for personnel exposure is judged to be significant and in which a single exposure to a very small quantity of a toxic fluid, caused by leakage, can produce serious irreversible harm to person on breathing or bodily contact, even when prompt restorative measures are taken."

The International Fire Code (IFC) contains provisions that deal with each type of hazardous material such as corrosives, cryogenics, flammable and combustible liquids, highly toxic materials, organic peroxides, oxidizers, pyrophorics, reactive materials, and water reactive solids and liquids. Independent of any seismic concerns, there are many provisions that apply to piping systems that convey these materials. There may be requirements, such as secondary containment, backup safety systems, emergency shut-off, monitoring or leak detection. NFPA 704, Standard System for the Identification of Hazards of Materials for Emergency Response (NFPA, 2007b) provides a classification and labeling system for hazardous materials as shown in Figure 6.4.5.1-4. The four-part diamond symbol is coded by color and position for type of hazard; the hazards associated with health, flammability and reactivity are further coded by degree of hazard. Use of appropriate hazard labeling for hazardous piping and associated containers or tanks of hazardous materials, as well as buildings housing such materials, is important so that fire fighters, emergency responders, and engineers performing postearthquake inspections will be aware of the hazards present.

- Requirements for seismic shut-off valves, excess flow switches, and excess flow valves for natural gas lines may vary by jurisdiction. While some jurisdictions now require seismic shut-off valves on some types or sizes of gas lines, many utilities do not encourage their use for residential service due to the difficulty in resetting them all following an earthquake. Some jurisdictions have tried to avoid this by requiring excess flow valves instead; check the applicable jurisdiction for specific requirements in your area.
- Seismic restraint details for pressure piping shown in Sections 6.4.3.1 through 6.4.3.8 can be adapted for use with hazardous fluid piping. Nevertheless, additional care is required in the design, installation, inspection, and maintenance of hazardous fluid piping systems. They may require specialized piping analysis, more frequent supports, ductile materials, continuous piping without joints, special welding procedures, special inspections, special purpose pipe clamps to avoid scratching the pipe or to prevent

corrosion, special insulation and consideration of large thermal differentials. Hazardous piping systems often require secondary containment such as double-walled piping. In addition, they may require monitoring, leak detection systems, excess flow switches, excess flow valves or seismic shut-off valves, use of protective sleeved connections, or cushion clamps. There are thousands of possible hazardous chemical streams and dozens of different pipe materials. Design of seismic restraints for these systems is a highly specialized field and may require coordination between the mechanical engineer, hazardous piping expert, and a seismic piping expert. There are currently few references available that deal specifically with the seismic issues related to these hazardous systems.

MITIGATION EXAMPLES



Special Hazards

This section is used to denote special hazards. There are only two NFPA 704 **approved** symbols:

OX This denotes an oxidizer, a chemical, which can greatly increase the rate of combustion/fire.

W Unusual reactivity with water. This indicates a potential hazard using water to fight a fire involving this material.

Figure 6.4.5.1-4 Example of NFPA 704 Fire Diamond used to label hazardous substances. The four divisions in the diamond are typically color-coded, with blue indicating level of health hazard, red indicating flammability, yellow (chemical) reactivity, and white containing special codes for unique hazards. Each of health, flammability and reactivity is rated on a scale from 0 (no hazard; normal substance) to 4 (severe risk). This labeling scheme is used in the U.S. but Canada, the European Union, Japan, etc. have different labeling schemes that should be followed for facilities outside the U.S.

Figure 6.4.5.1-5 Two examples of double walled piping used for secondary containment of hazardous fluids. Preassembled double walled pipe with centering devices or spacers separating the inner and outer pipe is available commercially, but as shown here, the outer pipe was installed and leak tested prior to pulling the inner pipe through. Note the yellow color coded labels indicate reactive materials; flow direction also marked prominently (Photos courtesy of Jeffrey Soulages, Intel Corporation).

Figure 6.4.5.1-6 Clockwise from top: a) Sleeved pipe connections where seismic anchorage consists of cushioned pipe clamp attached around outer sleeve and inner pipe not restrained longitudinally. b) Airgas canisters chained and strapped to supports, fitted with flexible hose, stainless steel piping (note blue label), and a row of valves. c) Label on tank shows example of European ADR danger labeling scheme. d) Excess flow valve for large gas tank (Photos courtesy of Jeffrey Soulages, Intel Corporation).

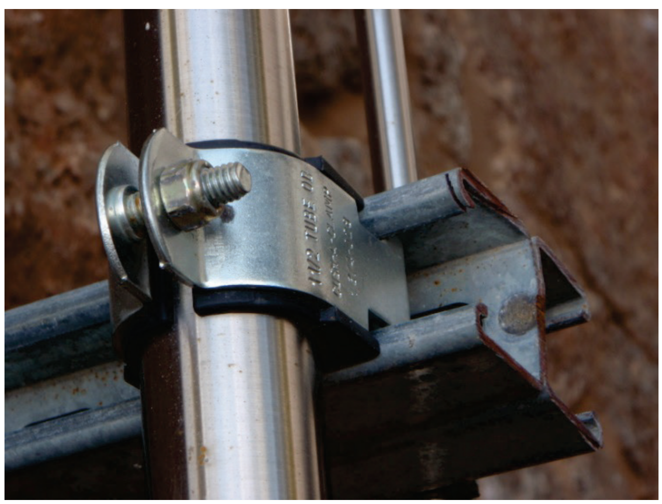
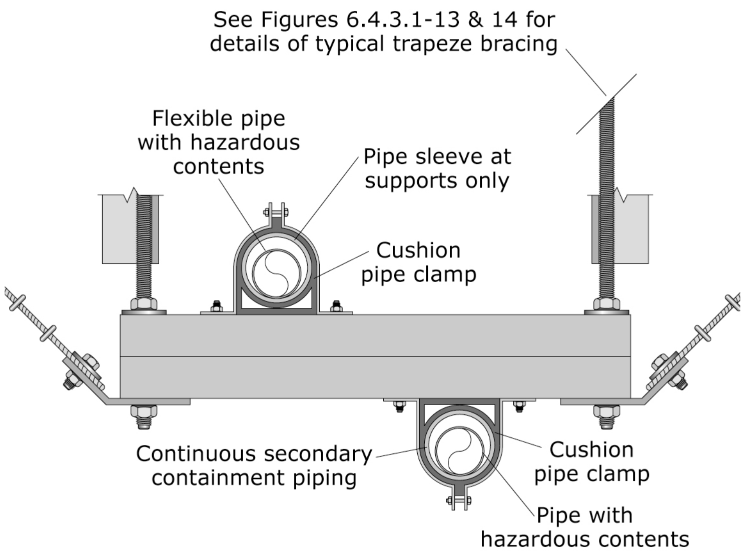


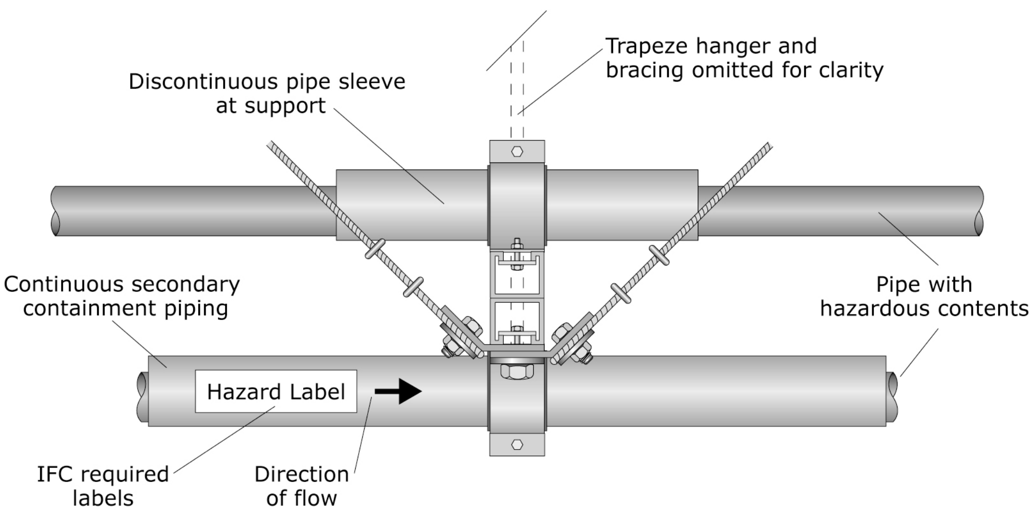
Figure 6.4.5.1-7 Process nitrogen piping outside engineering building on the UC Berkeley campus; strut clamp has rubber fittings to protect the stainless steel piping (Photos courtesy of Cynthia Perry, BFP Engineers).

Figure 6.4.5.1-8 Two examples of seismic shut-off valves in San Francisco Bay Area. Top photo at Marine Mammal Center; lower photo at six unit apartment building in Oakland (Photos courtesy of Cynthia Perry, BFP Engineers).

MITIGATION DETAILS



Front View



Side View

Figure 6.4.5.1-9 Hazardous piping examples (ER).