

## 6.4 Mechanical, Electrical, and Plumbing Components

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### 6.4.3 Pressure piping

#### 6.4.3.3 Flexible Connections, Expansion Joints, and Seismic Separations

This category covers the flexible piping connections required to accommodate differential movement at seismic separations between buildings or between floors, at the interface between piping and equipment, or to accommodate thermal expansion.

### Provisions

#### BUILDING CODE PROVISIONS

Displacement demands for flexible connections are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13. The objective is to provide sufficient capacity to accommodate the design building drifts without failure.

- Flexible connections are required between unbraced distribution systems (pipes, ducts, raceways, conduit, etc.) and braced equipment, braced distribution systems and unbraced equipment, and equipment that is supplied by distribution systems supported by the level above the component (drops).
- When equipment is supplied by drops, the length of the pipe, duct, conduit, or raceway that must accommodate the drift may be substantially less than the story height. For example, a floor mounted boiler, (which can be idealized as a rigid body) is supplied by pipes dropping from the floor level above. When the building displaces laterally, all the story drift must be accommodated by the pipe drops over the distance between the top of the boiler and the piping suspended from the floor above.
- At expansion and seismic separation joints, the distribution system must be able to accommodate the displacements between structures. Since the structures can move independently in any direction (towards each other, away from each other, etc.), the minimum and maximum displacements must be determined. Distribution systems crossing at expansion and seismic separations joints must accommodate movements that compress, extend, and shear the system crossing the joint.

#### RETROFIT STANDARD PROVISIONS

Flexible connections are considered deformation and acceleration sensitive in ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007). Flexible connections must be capable

of accommodating the required relative displacements. Detailed requirements depend upon the nature of the piping (or other distribution) system. Refer to the discussions of different distribution systems for more specific information.

### Typical Causes of Damage

- Differential movement between adjacent buildings or adjacent wings of buildings can cause damage to interconnected piping if relative movement has not been specifically accounted for. Differential movement between the fixed and base isolated portions of buildings can damage piping crossing the isolation plane. Failure to accommodate seismic displacements can rupture piping.
- Differential movement between anchored or restrained equipment and attached piping can cause damage to the equipment, the piping, or both.

### DAMAGE EXAMPLES

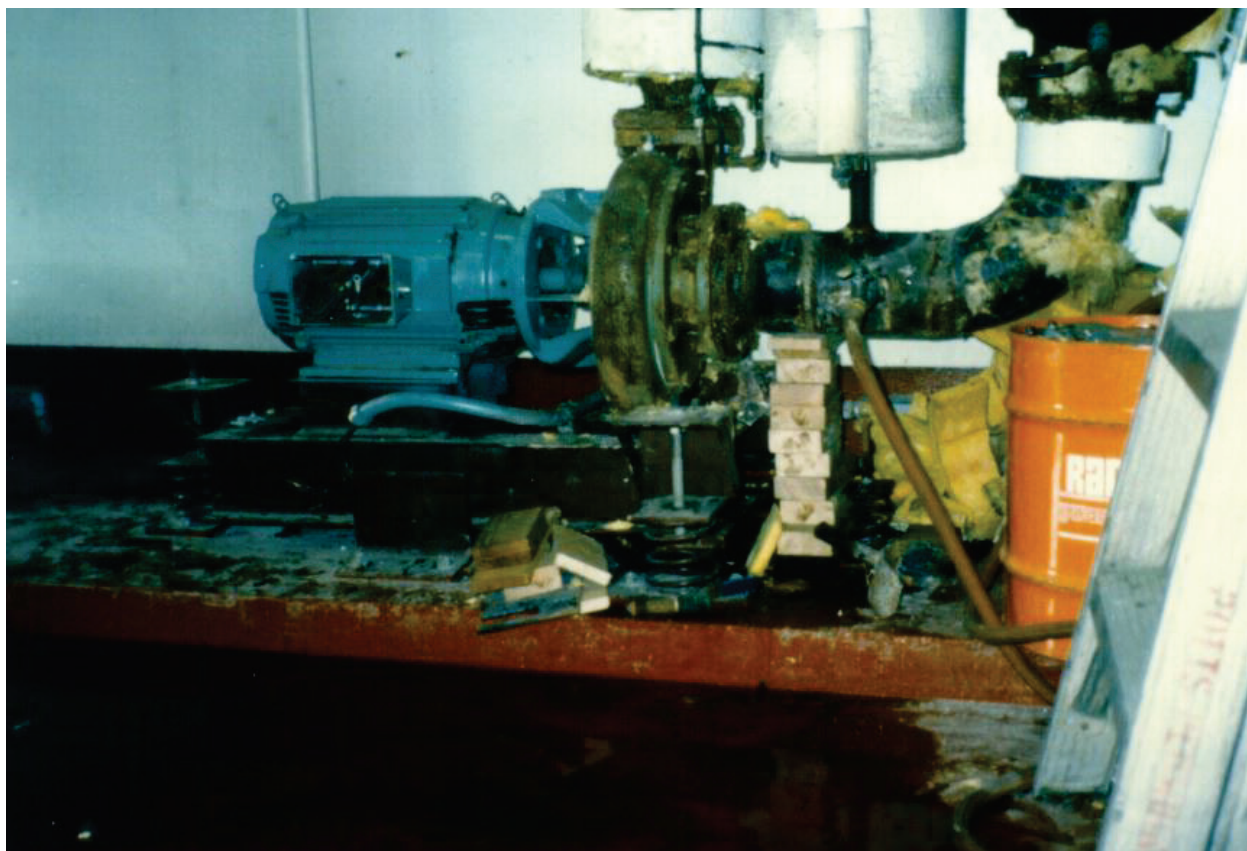


Figure 6.4.3.3-1 Failure at rigid connection to equipment on isolators without lateral restraint in the 1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of Mason Industries).

## Seismic Mitigation Considerations

- Flexible couplings are needed to accommodate relative displacement in a pipeline. Locations that may require flexible couplings include connections between piping and anchored equipment, wall or slab penetrations, seismic joints between buildings, and seismic joints in base isolated buildings. Selection of a specific coupling detail will depend on the magnitude of the anticipated relative displacements, the diameter of the pipe, and the type of pipe and its location.
- It is usually preferable for piping to be detailed to accommodate seismic relative displacements between the first seismic support upstream or downstream from connections to other seismically supported components or headers. This is preferably achieved by means of pipe flexibility or, where this is not possible, flexible supports. Piping not otherwise detailed to accommodate such seismic relative displacements must be provided with connections having sufficient flexibility in the connecting element or in the component or header to avoid failure of the piping. The option to use a flexible connecting element may be less desirable due to the need for greater maintenance efforts to ensure continued proper function of the flexible element. Several different types of flexible connections are shown; details for other conditions including floor and roof penetrations can be found in FEMA 414 *Installing Seismic Restraints for Duct and Pipe* (2004). Many vendors supply specialized hardware to create articulated joints or flexible tubing for these applications.
- Connections must provide sufficient flexibility to accommodate the expected differential movement in all directions.
- It is generally good seismic resistant design practice to provide a flexible connection between piping and equipment.

## MITIGATION EXAMPLES



Figure 6.4.3.3-2 Examples of flexible couplings that performed well in the 2010 magnitude-7 Haiti Earthquake; the building suffered relatively minor damage (Photo courtesy of Tom Sawyer, Engineering News Record).

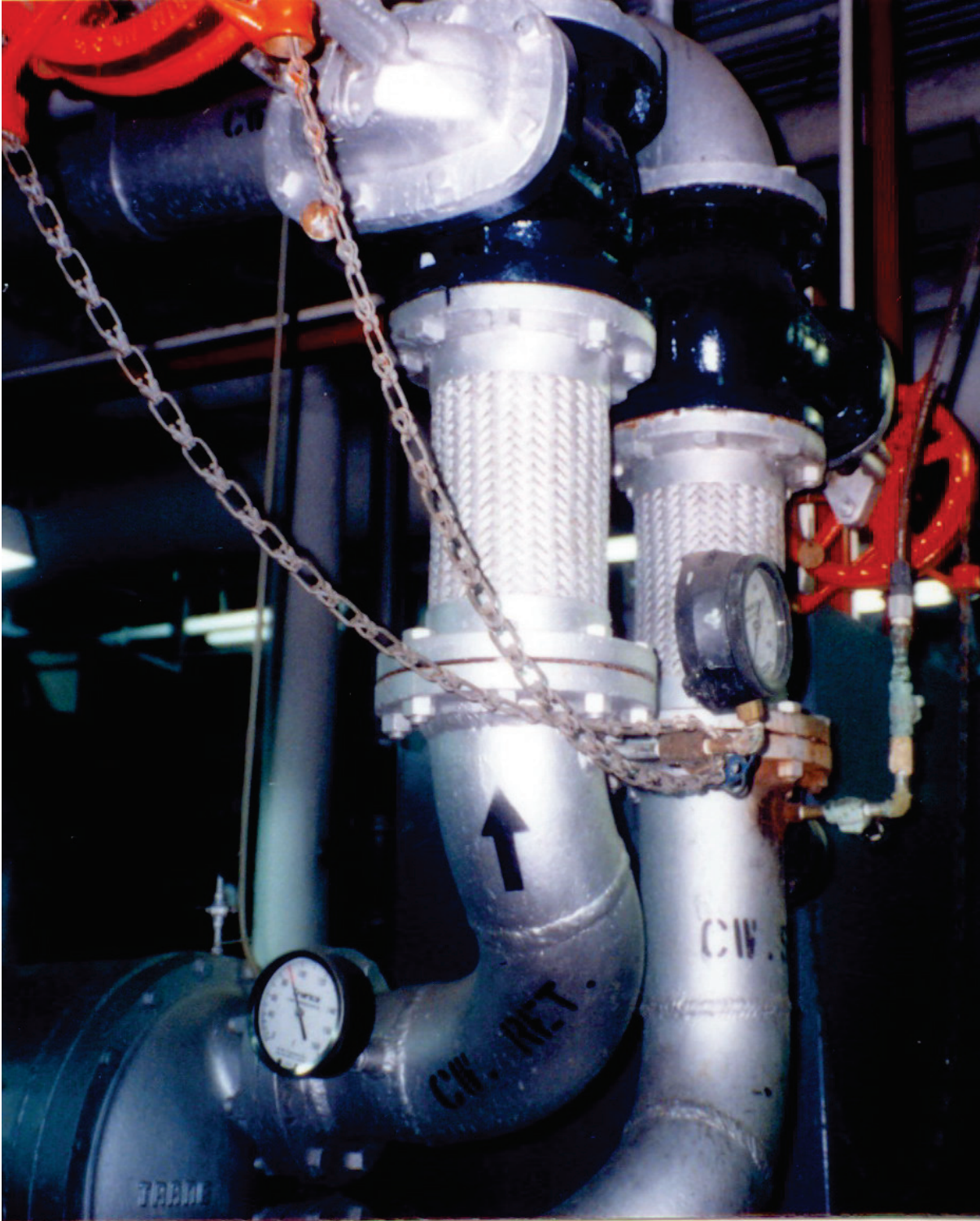


Figure 6.4.3.3-3 Flexible connection at pipe attachment to rigidly mounted tank (Photo courtesy of Wiss, Janney, Elstner, Associates).



Figure 6.4.3.3-4 Flexible pipe connections at rooftop expansion joint (Photo courtesy of Maryann Phipps, Estructure).

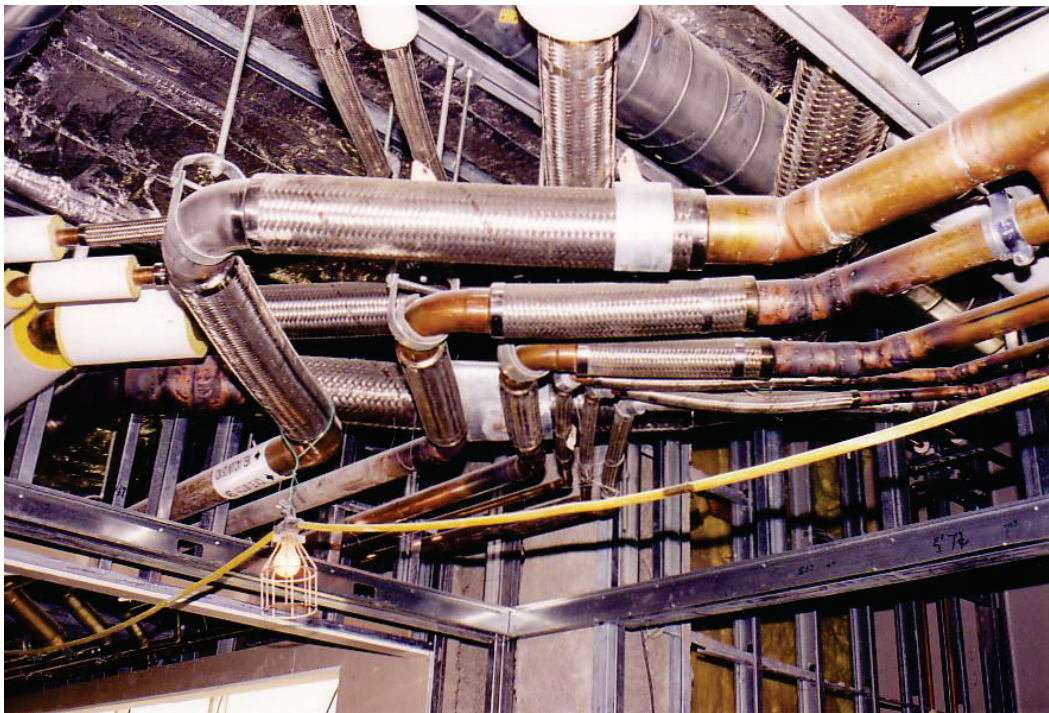


Figure 6.4.3.3-5 Flexible pipe connections at building separation (Photo courtesy of Mason Industries).

## MITIGATION DETAILS

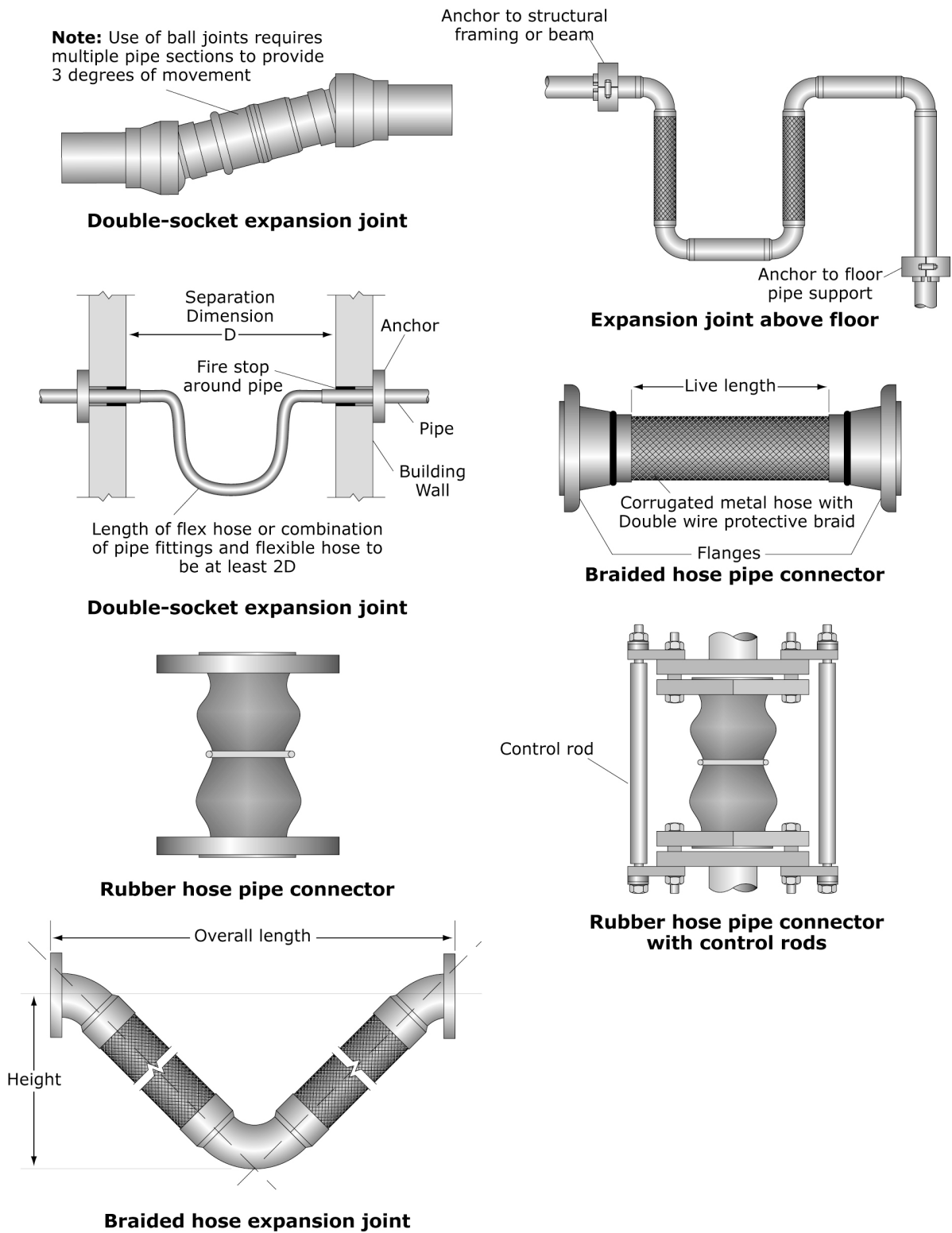


Figure 6.4.3.3-6 Flexible connections and expansion joints (ER).