6.4 Mechanical, Electrical, and Plumbing Components

6.4.3 Pressure Piping

6.4.3.6 Roof-Mounted Supports

This category covers roof-mounted supports for pressure piping. Roof-mounted supports may be used to support either horizontal or vertical pipe runs. Roof-mounted supports consist of wood blocking or steel shapes anchored to structural framing or a structural concrete slab and may be mounted with or without vibration isolation. These supports may be flush with the roof surface, have one cantilevered support member, one propped cantilever member, or be built up of multiple elements to form a trapeze or braced frame.

Provisions

BUILDING CODE PROVISIONS

ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, (ASCE, 2010) Chapter 13 classifies roof-mounted supports as "Component Supports." The design for component supports may be based on reference standards, proprietary systems, or calculated forces. When calculating seismic forces, the design coefficients for the supports are typically the same as those used for the piping. However, in no case should the value of R_p used for support design be greater than 6.0.

- ASCE/SEI 7-10 exempts piping from seismic bracing requirements in Seismic Design Category C if $I_p = 1.0$.
- ASCE/SEI 7-10 requires seismic design for all distribution systems including piping in Seismic Design Categories D, E, and F that weighs more than 5 pounds per linear foot.
- ASCE/SEI 7-10 exempts high-deformability or limited deformability piping (such as steel and copper pipe) where the pipe diameter is small (anywhere from 1 to 3 inch diameter depending on the Seismic Design Category and occupancy). Provisions must be made to accommodate anticipated movement (such as by providing flexible connections, as shown in Section 6.4.3.3) and to avoid impact with other structural or nonstructural components or to protect the piping in the event of such impact

The stiffness of the support should be designed to be compatible with its' intended function. For example, a relatively slender, flexible cantilever pipe support may not provide effective restraint for a stiff, large diameter steel pipe.

RETROFIT STANDARD PROVISIONS

The requirements for component supports in ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*, (ASCE, 2007) depend on the type of piping system. Refer to the discussions of different distribution systems for more specific application information. Roof-mounted supports are acceleration sensitive, and when retrofit is required, they must meet the force requirements of the standard.

Typical Causes of Damage

- Failure of pipe supports may result in damage to the support in question, damage to adjacent supports which are overloaded due to the initial failure, damage to the piping, damage to insulation or roofing, leakage of the contents, and outage of the system that the pipes support. Joints may fail if the layout of the seismic restraints is poor or where the restraints are inadequate for the anticipated forces and displacements. Piping damage may occur at locations where piping runs across roof separations or seismic joints if the piping has not been detailed to account for the differential movement.
- Seismic accelerations are often highest at the roof level and thus roof-mounted items are particularly vulnerable to failure unless properly designed. Several failure mechanisms exist for roof-mounted supports: failure at base if anchorage is undersized, yielding of cantilever elements causing excessive deflection, and buckling of braced elements if braces are undersized.
- Unrestrained piping supported directly on the roof is vulnerable to damage due to excessive movement. Unanchored wood sleepers may overturn or slide.
- Damage to roof-mounted items may also result in damage to the roofing membrane causing subsequent water damage.

DAMAGE EXAMPLES

Figure 6.4.3.6-1 Damaged supports and piping on roof-mounted HVAC unit in the 1994 magnitude-6.7 Northridge Earthquake (Photo courtesy of Mason Industries). Both the roof-mounted wood sleepers and strut supports failed.

Figure 6.4.3.6-2 Unrestrained wood sleepers on roof-mounted piping slid a foot in either direction in 2010 magnitude-6.5 Eureka Earthquake (Photos courtesy of Maryann Phipps, Estructure).

Figure 6.4.3.6-3 Unrestrained roof-mounted piping broke at the connection to the equipment in the 2010 Eureka Earthquake. Piping mounted on wood sleepers should typically be restrained to the roof, not free to slide (Photo courtesy of Maryann Phipps, Estructure).

Seismic Mitigation Considerations

- Pipe runs need vertical, lateral and longitudinal restraints. Roof-mounted supports can be used to provide restraint for any combination of these loads, can be designed for many different configurations, and may be used with or without vibration isolation. Longitudinal restraints require positive support to the pipe with a pipe clamp or welded lug; U-bolts do not provide effective longitudinal restraint.
- Seismic accelerations are often highest at the roof level; roof-mounted supports may need to be more robust than those located elsewhere in a building. They additionally need to be protected from corrosion and deterioration or they will be ineffective during an earthquake.
- If the pipe supports are vibration isolated, analysis is required to determine the appropriate seismic design force.In an existing concrete roof slab, care must be taken to locate rebar or post-tensioned tendons prior to drilling holes for anchor bolts. If the base plate for the pipe support is near the edge of a concrete curb or slab, care must be taken to provide sufficient edge distance and embedment for the anchor bolts. Some

types of anchors are not recommended for use with vibratory loads. FEMA 414, *Installing Seismic Restraints for Duct and Pipe* (2004) provides additional precautions regarding the installation of anchor bolts.

- Weatherproofing is an important consideration for roof-mounted supports; any penetration of the roof membrane must be adequately sealed to prevent roof leakage. Refer to Section 6.4.3.8 for additional discussion of pipe penetrations.
- Seismic restraint hardware for any exterior exposure should be specified using materials or coatings to reduce corrosion and may require periodic painting or replacement to maintain the effectiveness of the restraint. Items exposed to salt air, or deicing compounds such as in a parking structure, may be especially at risk.

MITIGATION EXAMPLES

Figure 6.4.3.6-4 Roof-mounted supports with vibration isolation (Photo courtesy of Mason Industries).

MITIGATION DETAILS

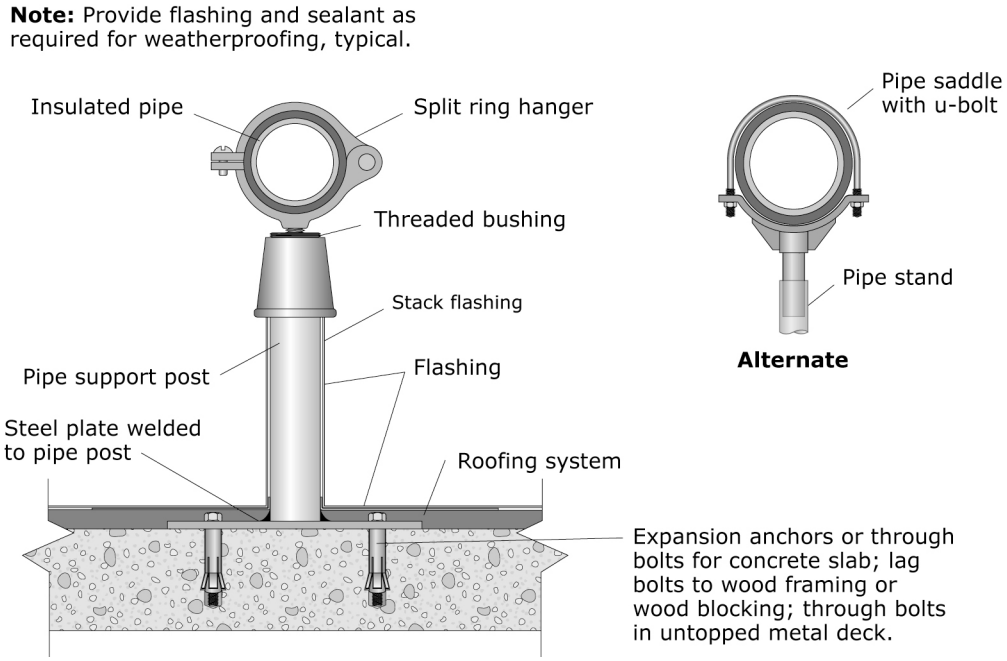
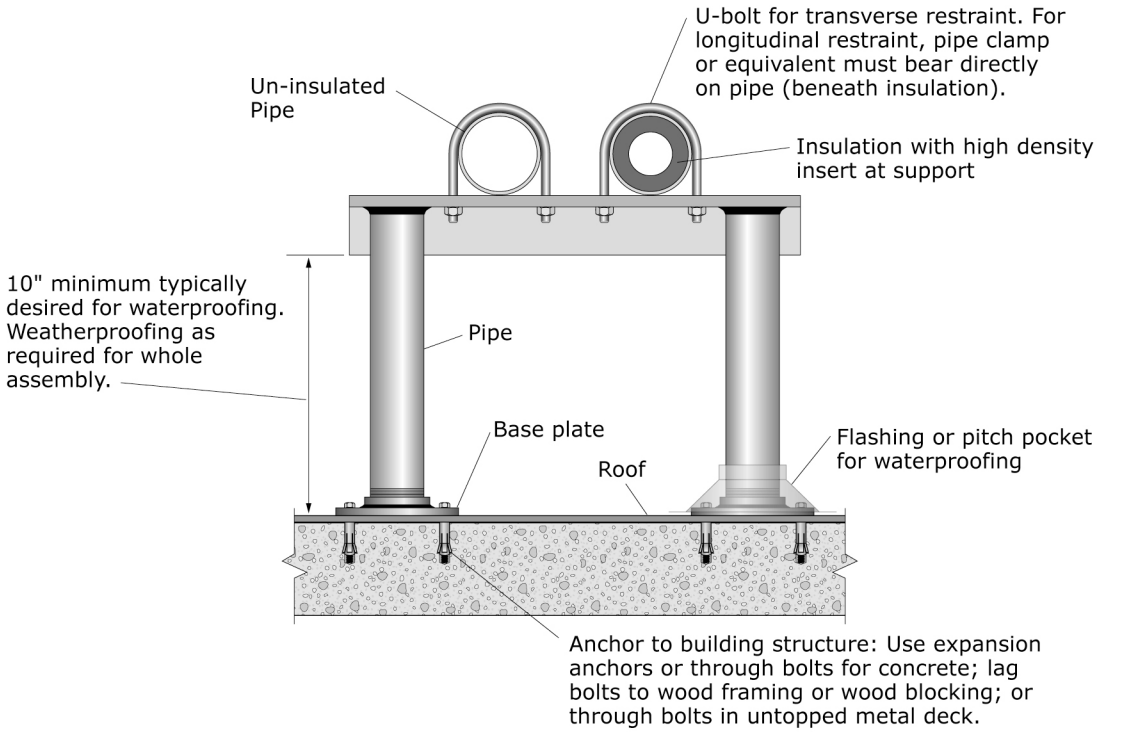


Figure 6.4.3.6-5 Roof-mounted single vertical pipe support (ER).



Note: Provide flashing and sealant as required for weatherproofing, typical.

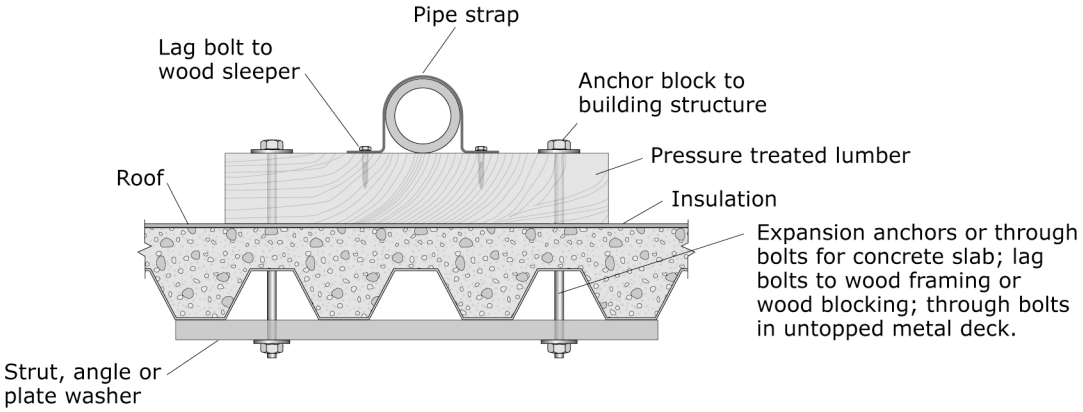


Figure 6.4.3.6-6 Roof-mounted pipe stand and sleeper anchored to slab (ER).