

6.4 MECHANICAL, ELECTRICAL, AND PLUMBING COMPONENTS

6.4.1 MECHANICAL EQUIPMENT

6.4.1.1 BOILERS, FURNACES, PUMPS, AND CHILLERS

This category includes equipment such as boilers, furnaces, humidifiers, pumps, chillers and similar that are anchored to a concrete floor or housekeeping pad. These items are either rigidly anchored or have vibration isolation. Current codes require anchorage for all equipment weighing over 400 pounds, equipment weighing over 100 pounds that are subject to overturning, and items weighing over 20 pounds that are mounted over 4 feet above the floor.

TYPICAL CAUSES OF DAMAGE

- The primary concern is that equipment may slide, tilt or overturn. Heavy equipment may be anchored to an unanchored or poorly reinforced housekeeping pad and the pad may shift or break.
- Movement of equipment may cause loss of connections to fuel and exhaust lines, relief valves, electrical lines, piping, or ductwork. Fluids such as fuel or refrigerant may leak.
- Function and operability of equipment may be compromised; this is especially critical for hospitals and other essential facilities that must maintain post-earthquake operations.

Damage Examples

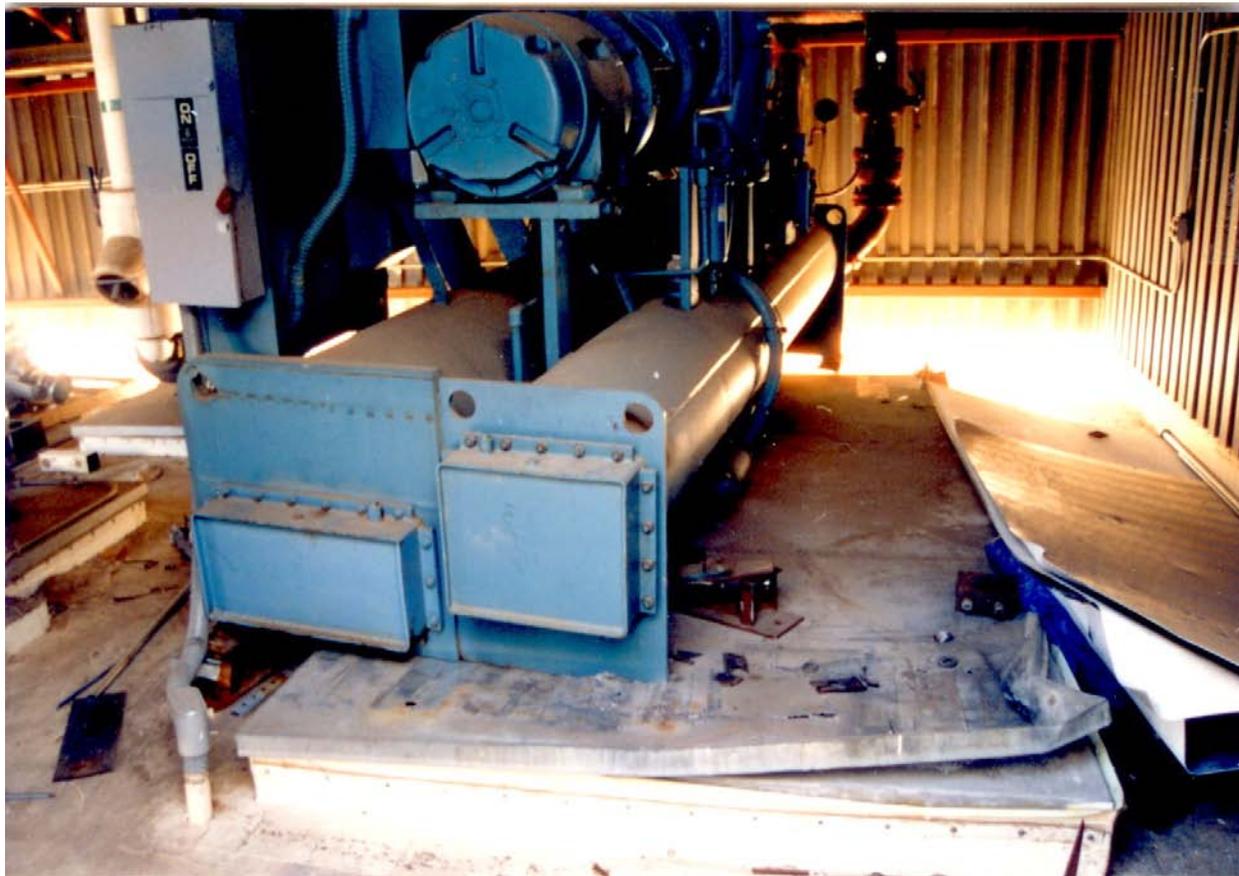


Figure 6.4.1.1-1 Failed chiller mounts due to insufficient uplift resistance in the 1994 magnitude-6.7 Northridge Earthquake ((Photo courtesy of Wiss, Jenney, Elstner Associates).



Figure 6.4.1.1-2 Pumps with rigid anchorage to housekeeping pad in the 2010 magnitude-8.8 Chile Earthquake; housekeeping pad not anchored to base slab and slid horizontally several inches (Photo courtesy of Eduardo Fierro, BFP Engineers).

SEISMIC MITIGATION CONSIDERATIONS

- The details shown depict rigid anchorage of mechanical equipment to a concrete slab or housekeeping pad. Verify that the slab and/or housekeeping pad are adequate to resist the imposed loads. Rigidly mounted equipment should have flexible connections for the fuel lines and piping.
- For equipment with vibration isolation, restraints ("snubbers") are required; see Section 6.4.1.3 for equipment with vibration isolation. These snubbers should not be rigidly connected to the equipment, but instead allow for a small amount of ordinary vibration movement while preventing large seismic movements.
- HVAC equipment or other items required for use in a hospital or essential facility would be classified as designated seismic systems and may require engineering calculations, equipment certification and special inspections. Check with the jurisdiction for specific requirements.
- To see additional examples for specific equipment and different anchorage conditions, refer to FEMA 412 *Installing Seismic Restraints for Mechanical Equipment* (2002) and FEMA 414 *Incremental Seismic Restraints for Duct and Pipe* (2004).

Mitigation Examples



Figure 6.4.1.1-3 Added lateral capacity provided for skid-mounted equipment added following the 2001 Peru Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers).



Figure 6.4.1.1-4 Bolted connection to steel skid with added shear lugs (Photo courtesy of Eduardo Fierro, BFP Engineers).



Figure 6.4.1.1-5 Alternate detail for skid mounted equipment (Photo courtesy of Eduardo Fierro, BFP Engineers).

Mitigation Details

Note: Do not add shims under equipment with sheet steel housings. If the concrete floor/pad is irregular, reinforce housing or grout solid beneath equipment for uniform bearing.

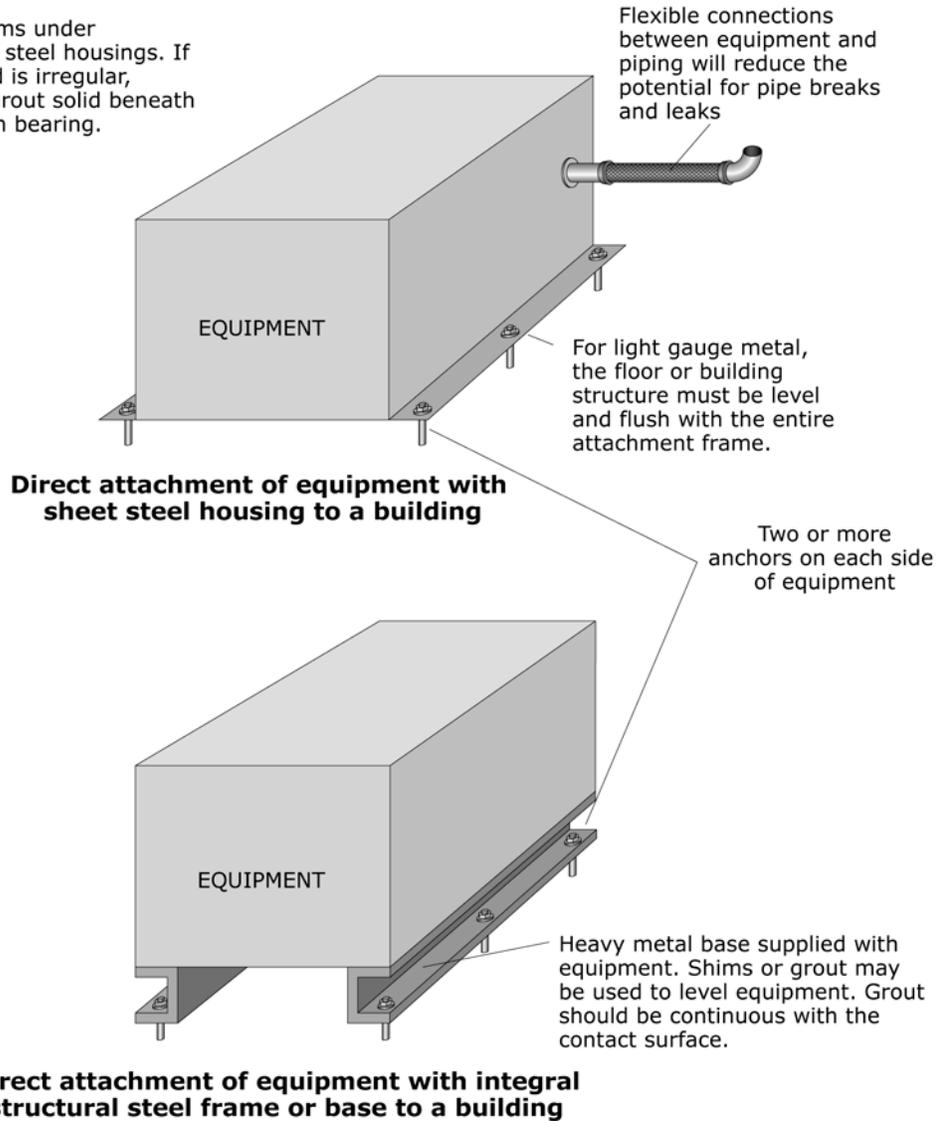


Figure 6.4.1.1-6 Floor-mounted equipment - integral base (ER).

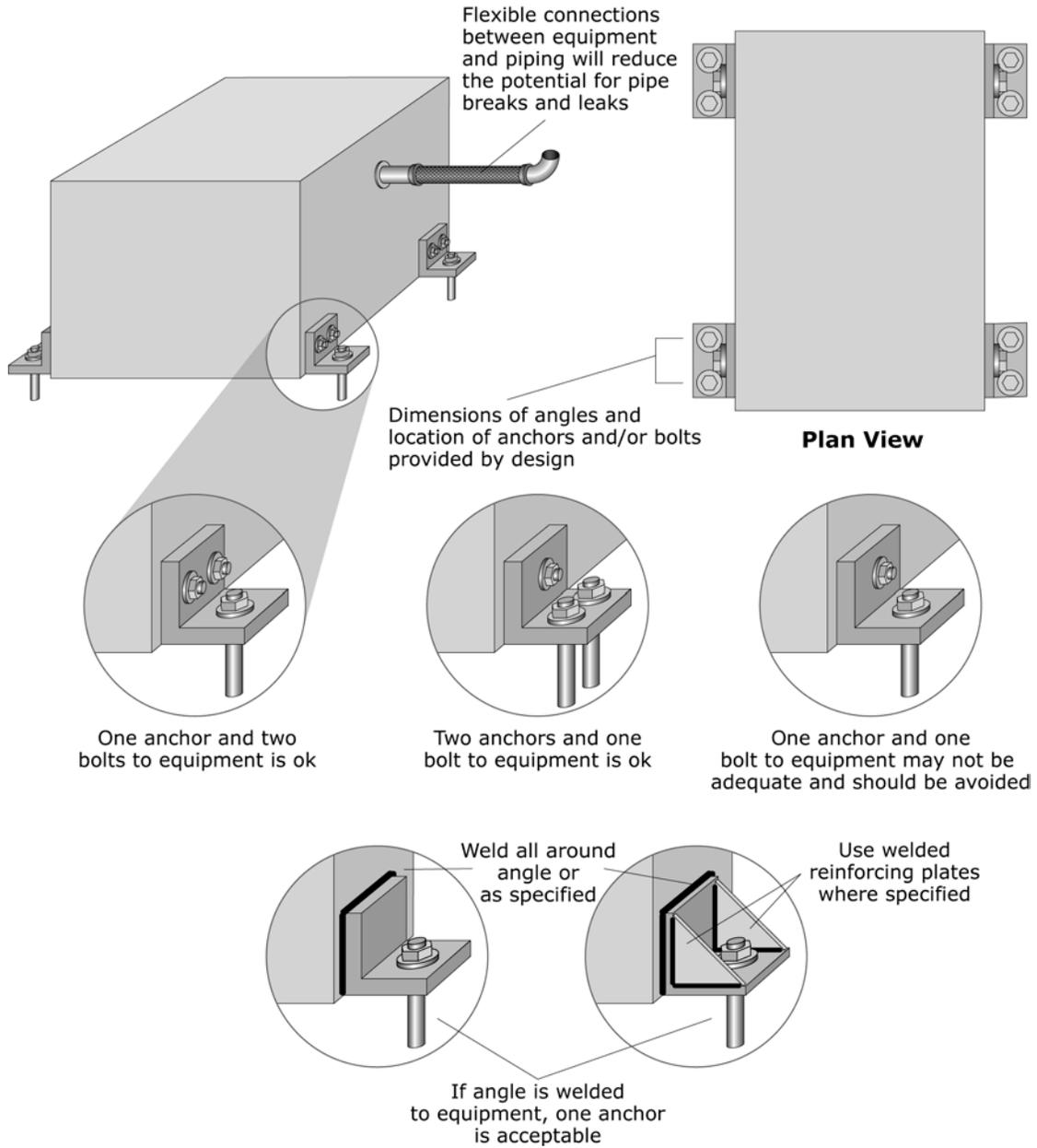


Figure 6.4.1.1-7 Floor-mounted equipment - added angles (ER).