6.4 Mechanical, Electrical, and Plumbing Components

6.4.1 Mechanical Equipment

6.4.1.4 HVAC Equipment without External Vibration Isolation

This includes dry-side HVAC equipment, typically of sheet metal construction, that is rigidly mounted to the floor, wall or roof, and components that are internally isolated. While internally isolated equipment is rigidly attached to the structure, internal components are installed on vibration isolators.

Provisions

BUILDING CODE PROVISIONS

Seismic loads for HVAC equipment without external vibration isolation are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13. The principal objective is to prevent the component from sliding or overturning.

- Seismic loads for HVAC equipment without external vibration isolation are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13. The design forces for internally isolated components are substantially higher than those for non-isolated components.
- ASCE/SEI 7-10 requires anchorage for all equipment in Seismic Design Categories D, E, and F for all equipment weighing over 400 pounds, and items weighing over 20 pounds that are mounted over 4 feet above the floor. Lighter items may be exempt if the component Importance Factor $Ip = 1.0$.
- Items that are exempt from the anchorage requirements noted above are still required to be positively anchored to the structure. The anchorage need not be designed or detailed on the construction documents. They must also be provided with flexible connections between the equipment and associated pipes, ducts, or conduits or provided with other means to protect the connections from damage.

RETROFIT STANDARD PROVISIONS

In ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007), HVAC equipment without external vibration isolation is classified as force controlled. ASCE/SEI 41-06 requires compliance with the anchorage provisions of the standard when:

- The performance level is Immediate Occupancy

- The performance level is Life Safety in high seismicity areas, if
  - The item is gas-fired.
  - The item is part of an emergency power system,
  - The items weighs more than 400 pounds and is 6 feet or more in height,
  - The item is unanchored, weighs over 100 pounds, is 6 feet or more in height, and is subject to overturning. These items may be exempt if they have a factor of safety greater than 1.5 against overturning when design loads are applied.
  - The item weighs over 20 pounds and is mounted over 4 feet above the floor.

Typical Causes of Damage

- Unanchored or inadequately anchored items can slide, tilt, overturn, or fall.
- Connections of fuel lines, electrical lines or ductwork may be damaged; machinery may cease to function due to misalignment.
- Internally isolated components may experience substantially larger seismic forces than those without internal isolation. This results in higher demands on the component anchorage, and increases the vulnerability of the component to internal shaking damage.

DAMAGE EXAMPLES

Figure 6.4.1.4-1 Poorly anchored compressor jumped off the undersized anchor bolts in the 2010 magnitude-8.8 Chile Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers).

Figure 6.4.1.4-2 Unanchored rooftop units thrown off their supports during an earthquake (Photo courtesy of Maryann Phipps, Estructure).

Figure 6.4.1.4-3 Numerous poorly anchored rooftop units toppled in the 2010 Chile Earthquake (Photos courtesy of Rodrigo Retamales, Rubén Boroschek & Associates).

Seismic Mitigation Considerations

- See Section 6.4.1.1 for rigid floor mount details and Section 6.4.1.3 for vibration isolation floor mount details.
- Special consideration is needed for rooftop units. Such units are typically mounted on curbs or platforms to facilitate waterproofing and flashing. Curbs may be custom-built on site or premanufactured. Detailing for seismic restraints must include a connection between the equipment and the curb and the curb and the roof framing. In addition, the curb itself must be sufficiently strong to deliver earthquake forces from the unit to the roof. If the equipment is internally isolated, the design forces for the anchorage should be increased appropriately.
- See FEMA 412 *Installing Seismic Restraints for Mechanical Equipment* (2002) and FEMA 414 *Installing Seismic Restraints for Duct and Pipe* (2004) for details for wall-mounts, roof-mount with flashing details, ducts and piping, and additional information regarding hardware and installation.

MITIGATION DETAILS

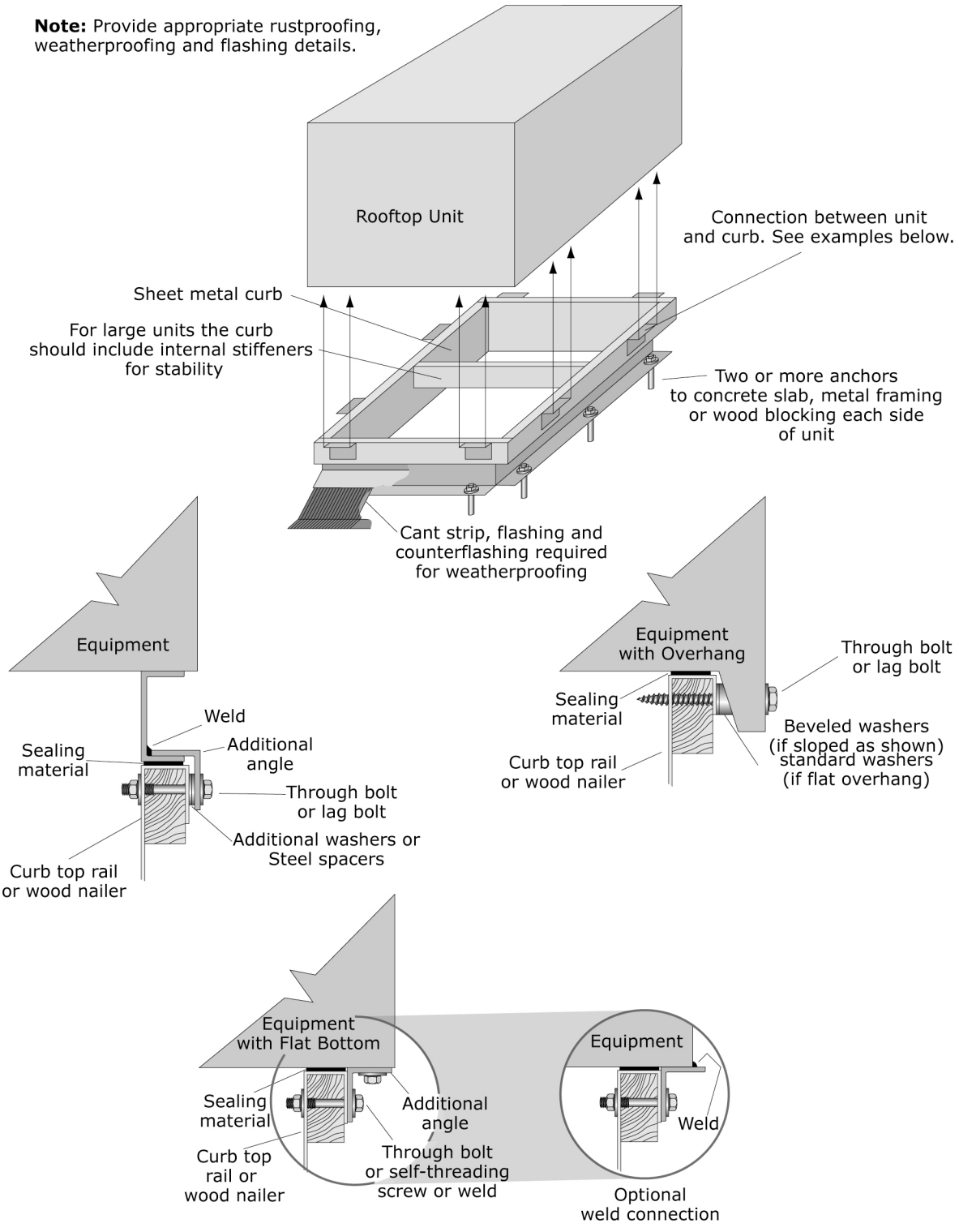

Figure 6.4.1.4-4 Rooftop HVAC equipment (ER).