6.4 Mechanical, Electrical, and Plumbing Components

6.4.7 Electrical and Communications Equipment

6.4.7.2 Emergency Generators

Emergency generators are essential for postearthquake operations for many types of facilities. These range from small residential size generators to large systems required to maintain hospital or other essential operations. Emergency generators are often mounted on vibration isolators.

Provisions

BUILDING CODE PROVISIONS

Seismic loads for emergency generators 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.

- If the emergency generator is required to function for life safety purposes, ASCE/SEI 7-10 classifies them as *Designated Seismic Systems*, with an Importance Factor $I_p = 1.5$. It may also require seismic qualification (shake table testing) to verify that the generator will function following and earthquake.
- Generators are often mounted on vibration isolators. The seismic design force for vibration isolated equipment is doubled if the "air gap" (the distance between the equipment support frame and the restraint) is greater than 0.25 inches.
- When checking the adequacy of an emergency generator for seismic forces, the load path from the generator, through any supporting framing to the ground or structural slab must be evaluated. For example, some emergency generators are "packaged: units," where all of the necessary components (prime mover, generator, radiator, fuel tank, etc.) are mounted on a skid or frame. Another common approach is to mount the generator on top of the fuel tank. In either case, a load path of adequate strength and stiffness must be confirmed. Supporting elements, especially fuel tanks used as supports, may require reinforcement to withstand the seismic loads.

REHABILITATION CODE PROVISIONS

In ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*, (ASCE, 2007) emergency generators are not covered in Section 11, Architectural, Mechanical, and Electrical Components

as a separate item. The closest requirements are those for electrical and communications equipment, Section 11.10.7. Electrical and communications equipment are subject to the provisions of the standard when the performance level is Immediate Occupancy. The requirements also apply when the performance level is Life Safety in high and moderate seismicity areas, and the equipment is over 6 feet in height and weighs more than 20 pounds. Regardless of these provisions, it is prudent to apply the nonstructural evaluation and retrofit requirements for all occupancies and performance levels due to the essential nature of emergency generators.

Acceptance criteria for electrical equipment focus on providing adequate anchorage for seismic forces.

Typical Causes of Damage

- Emergency generators may slide, tilt, or overturn. Internal elements may be damaged by inertial forces.
- Unanchored or poorly reinforced housekeeping pads may fail, resulting in excessive movement of the supported equipment.
- Vibration isolators can fail causing excessive generator movement.
- Failure of the emergency power generating system may be caused by the failure of any of the component parts including generator, fuel tank, fuel line, batteries and battery racks.

Seismic Mitigation Considerations

- Working around electrical equipment can be extremely hazardous. Read the Electrical Danger Warning and Guidelines in Section 6.6.8 of this document before proceeding with any work.
- Many equipment items can be supplied with a structural steel base, shop welded brackets, or predrilled holes for base anchorage. For any new equipment, request items that can be supplied with seismic anchorageprovisions.
- For equipment mounted on a free-standing concrete pad, make sure pad is large enough to resist seismic overturning of generator.
- Check the anchorage for all the component parts of the emergency power generation system; failure of any one of them could compromise the postearthquake performance of the system. Provide flexible connections for the fuel line, exhaust ducting and any other connected utility.

- See Section 6.4.1.1 for additional base anchorage details. Refer to FEMA 413 *Installing Seismic Restraints for Electrical Equipment* (2004) for general information on seismic anchorage of electrical equipment.

MITIGATION EXAMPLES

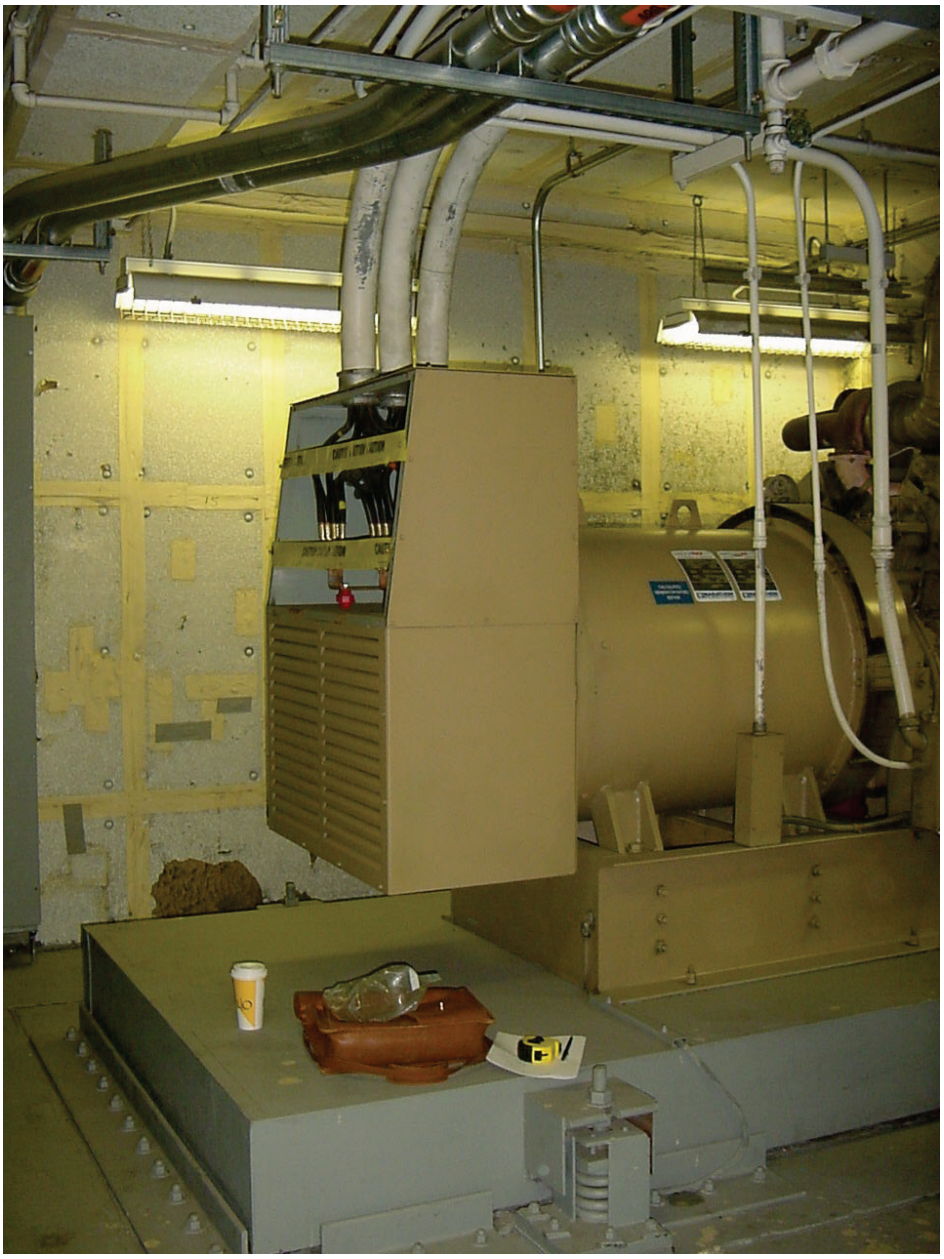

Figure 6.4.7.2-1 Emergency generator is anchored to a concrete inertia base. The inertia base is mounted on spring isolators and restrained by steel angle snubbers on all sides (Photo courtesy of Maryann Phipps, Estructure).

Figure 6.4.7.2-2 Emergency generator with skid mount on housekeeping pad; shear lugs added following the 2001 Peru Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers).

MITIGATION DETAILS

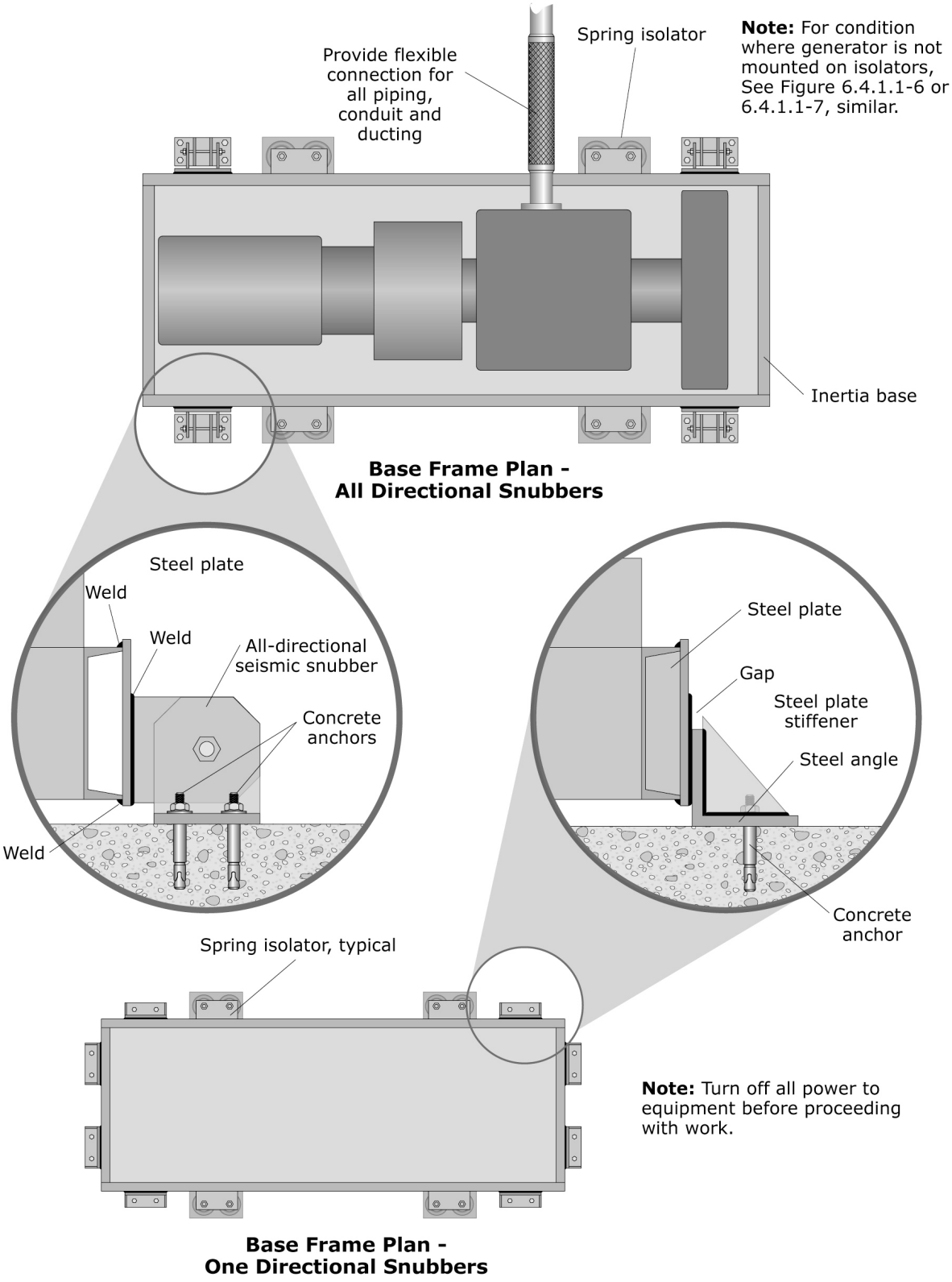

Figure 6.4.7.2-3 Emergency generator (ER).