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RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to moderate

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Derailed elevator cars.
- Inoperable elevators

REFERENCE FIGURE FOR EXAMPLE OF DAMAGED EQUIPMENT

- 3.157

Elevator Systems—Traction Elevators

Counterweight Guide Rails

Ayres and Sun (1973) reported 674 counterweights that had been dislodged from their guide rails as a result of the 1971 San Fernando earthquake. One-sixth of the counterweights actually damaged the elevator cars.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment

SEISMIC SPECIFICATION

- SDS-1

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis
  - Rail anchorage.
- Stress analysis.
  - On the rail.
- Design team judgment
  - Specify proper counterweight roller guides (Figure 3.43) that have been designed for the earthquake environment.

REFERENCE FIGURES FOR INSTALLATION DETAILS

- 4.22, 4.23.

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Moderate to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Potential for personnel injury
- Counterweights derailed.

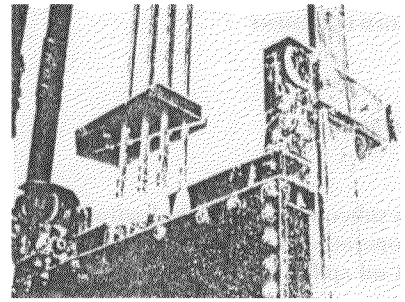

FIGURE 3.43. Counterweight guide rails showing rail anchorage and counterweight roller guides at top of counterweight

- Counterweights damage elevator car
- Inoperable elevator system

REFERENCE FIGURES FOR EXAMPLES OF DAMAGED EQUIPMENT

- 3.154, 3.155, 3.156, 3.157, 3.158

Elevator Systems—Traction Elevators

Hoist Machine

Hoist machine failure can cause the hoist cables to become entangled, which in turn makes the entire elevator system inoperable

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment.

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis
  - Base anchorage of hoist machine to structural member (Figure 3.44)

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.27.

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Shifted hoist machine.

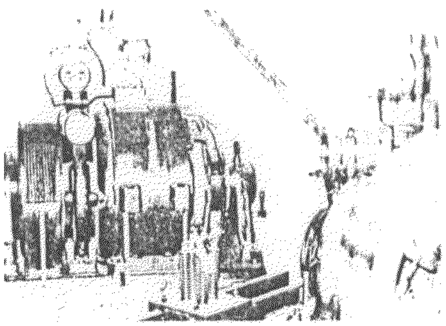

FIGURE 3.44. Gearless hoist machine showing base anchorage and cable guide.

- Toppled hoist machine.
- Tangled hoist cables.
- Inoperable elevator.

Elevator Systems—Traction Elevators

Motor Control Panel

Motor control panels with dynamically sensitive control devices (Figure 3.45) require more stringent qualification programs than panels with all solid-state subcomponents.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment.

SEISMIC SPECIFICATION

- SDS-1

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis.
    - Base anchorage of control panels with solid-state subcomponents.
- Seismic test.
    - Control panels with dynamically sensitive switches, and so on.

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.25.

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to major.

FIGURE 3.45. Motor control panels showing dynamically sensitive switches. This tall, slender panel is neither base anchored nor top braced.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Shifted equipment.
- Toppled equipment.
- False signaling.
- Inoperable equipment.

REFERENCE FIGURE FOR EXAMPLE OF DAMAGED EQUIPMENT

- 3.159.

Elevator Systems—Traction Elevators

Motor Generator

Motor generators have commonly failed in past earthquakes because of inadequate anchorage (see Figure 3.46). They must be base anchored and provided with flexible electric connections.

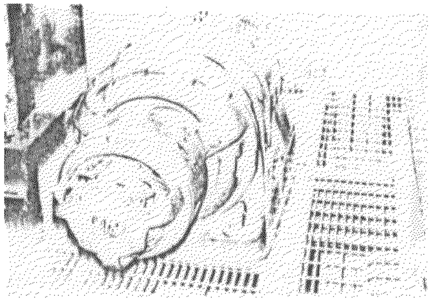

FIGURE 3.46. Unsecured motor generator sitting atop floor grating. The electric wiring to this generator has been installed without slack, which increases its failure potential.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment.

SEISMIC SPECIFICATION

- SDS-1

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis.

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.29

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Shifted equipment
- Inoperable elevators

REFERENCE FIGURES FOR EXAMPLES OF DAMAGED EQUIPMENT

- 3.159, 3.160, 3.161

Elevator Systems—Traction Elevators

Selector Panel

Selector panels with dynamically sensitive subcomponents can cause the inoperability of the elevator system through false signaling, and so on if not adequately braced (Figure 3.47).

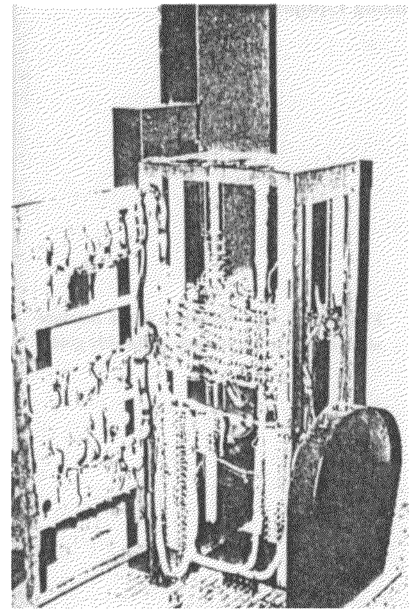

FIGURE 3.47. This selector panel has only been anchored to the floor grating, not the steel structure below. This is not adequate seismic protection.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment.

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis.
  - Base anchorage and top bracing for solid-state panels.
- Seismic test.
  - Panels with dynamically sensitive subcomponents.

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.26.

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Shifted equipment.
- Toppled equipment.
- Pounding of adjacent equipment or walls if not properly braced.
- Inoperability due to false signaling and so on (transient failure).

Emergency Power Supply Systems

Emergency power supply systems are the backbone of all facilities following most major disasters. Widespread power failures commonly accompany destructive earthquakes. More than any of the other systems discussed in this book, emergency power supplies need to be approached from the systems point of view for seismic qualification. A single failure of many subcomponents in the system can place the entire system out of operation. This can lead to the inoperability of other equipment items that may be required to perform critical functions. The interrelationships of functioning systems was demonstrated in the 1979 Imperial Valley earthquake. At one essential facility, a water main burst and flooded the emergency power supply room. As a result of the flooding, the emergency power supply system could not function and critical communications were hampered because of a lack of power. Inadequate qualification of the emergency power supply system and its components or adjacent systems will almost certainly lead to critical failures in future earthquakes.

SYSTEM SEISMIC CATEGORY

- "A" critical system.

SYSTEM FOUND IN

- Business establishments.
- Communication centers.
- Computing/data processing centers.
- Emergency operating centers.
- Fire stations.
- Government administration buildings.
- Hospitals.
- Police stations.
- Schools.

Emergency Power Supply Systems

Battery

To start larger systems, more than one battery is required. Battery racks should be adequately anchored and the batteries should be anchored or restrained within their racks (Figure 3.48). Electric cables should have plenty of slack and not be pulled tight for aesthetic reasons.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment.

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis
  - For battery rack anchorage
- Design team judgment
  - For cable slack and battery restraint within the rack.

REFERENCE FIGURES FOR INSTALLATION DETAILS

- 4.30, 4.31.

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Battery racks may topple if not adequately anchored.

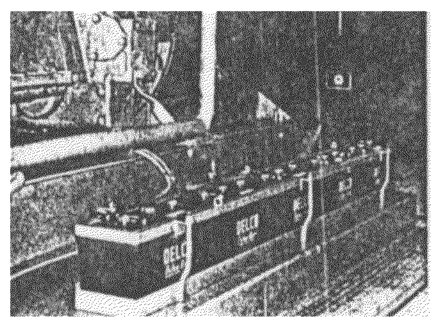

FIGURE 3.48. Batteries should be anchored as shown here and flexible electrical connections should be provided.

- Battery cells may crack if not restrained within their racks; acid may spill from cracked batteries.
- Electric cables tear loose from the terminals, often with battery case damage, if installed too tightly.
- Emergency power supply system cannot function.

Emergency Power Supply Systems

Exhaust Unit

Exhaust gases are harmful to facility personnel if leaks should develop. Flexible connections provide leak protection and should be provided between the manifold/muffler (Figure 3.49) and muffler/building interfaces.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment

SEISMIC SPECIFICATION

- SDS-1.

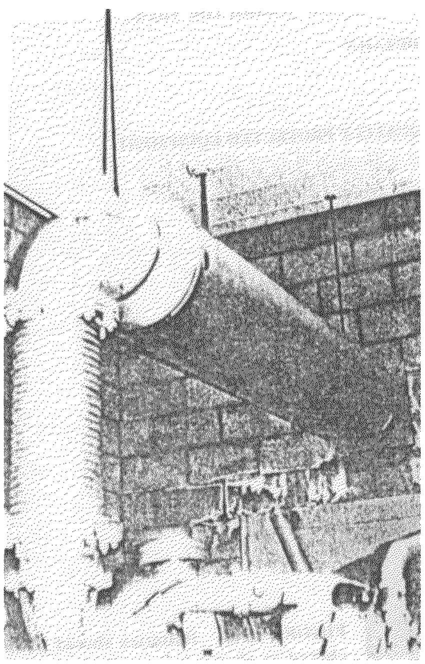

FIGURE 3.49 Flexible connection between the exhaust manifold and muffler should be employed as shown here. Lateral bracing also should have been provided for the muffler unit.

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis.
  - For suspension system
  - Lateral bracing.
- Dynamic analysis.
  - To determine maximum displacements
- Design team judgment.
  - Use manufacturer recommended flexible connections

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.42

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Inadequate suspension system can cause silencer collapse.
- Rigid exhaust pipe connections are likely to fail.
- Potential for personnel injury if exhaust gases leak into the building.
- System is likely to remain operational even if silencer supports fail.

Emergency Power Supply Systems

Fuel Supply Equipment

The day tank (Figure 3.50) generally holds enough fuel for 24 hours of continued operation. To assure that variations in the time frame requirement are met it is necessary to refer to local codes. The day tank may be buried or fixed to the walls or floor of the facility. Damage would generally not be expected if the day tank is securely anchored.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis
  - Fixed day tank.
- No specific requirements
  - Buried day tank.