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SEISMIC QUALIFICATION APPROACH

- Design team judgment.
  - Swing arm restrainers when not in use.
- Equivalent static coefficient analysis.
  - Base anchorage at wall connection.

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.52

RELATIVE DEGREE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- None to minor.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Possible collision with other equipment while X-ray unit is swinging.

Medical Systems

X-Ray, Fixed

Fixed X-ray equipment is required (Figure 3.125) for adequate patient care immediately after a major earthquake. Equipment subcomponents are commonly precariously or eccentrically mounted and are highly sensitive to dynamic motions.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment

SEISMIC SPECIFICATION

- SDS-1

SEISMIC QUALIFICATION APPROACH

- Equivalent static coefficient analysis
  - Base analysis
- Dynamic analysis.
  - Subcomponents.
  - Frame analysis.
- Seismic test.
  - Generic qualification by manufacturer.

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.75

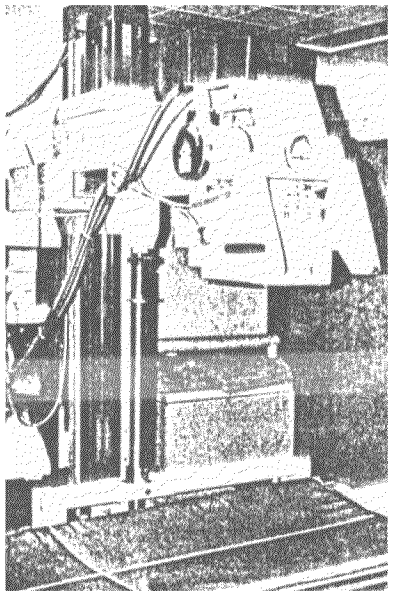

FIGURE 3.125 Typical X-ray units require base anchorage

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to moderate.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Equipment malfunction.
- Frame racking.
- Equipment toppling because of underdesigned anchorage.
- Equipment pounding.
- General cleanup required

Medical Systems

X-Ray, Portable

Portable X-ray equipment (Figure 3.126) is commonly left unanchored in hallways and work spaces when it is not in use, inviting disaster.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment.

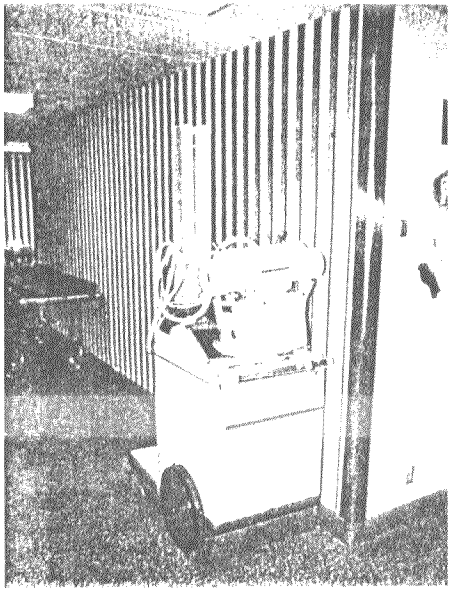

FIGURE 3.126. Unsecured portable X ray unit

SEISMIC SPECIFICATION

- SDS 1.

SEISMIC QUALIFICATION APPROACH

- Design team judgment.
  - Provide storage space when equipment is not in use
- Equivalent static coefficient approach.
  - Anchorage when equipment is not in use

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.69

RELATIVE DEGREE OF DAMAGE OF INADEQUATELY PROTECTED EQUIPMENT

- Minor to moderate

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Toppling.
- Runaway equipment
- Collision with other equipment
- Equipment malfunction.
- General cleanup required.

Motion Restraint Systems (Courtesy California Dynamics Corporation)

Unless protected, resiliently supported equipment is vulnerable to earthquake caused damage. Excessive displacements relative to the building can tear connections and excessive equipment velocities endanger equipment and surroundings from hammering impacts. Motion restraints, if properly employed by the design team, can protect the equipment without compromising day-to-day vibration isolation performance unless earthquake criteria are unusually severe.

A motion restraint (or snubber) must be structurally adequate and properly anchored or it will merely give the illusion of protection. The low tensile strength of concrete often dictates extraordinary measures such as embedment of steel beams in concrete floors. Proper design, however, can often avoid this costly procedure and drilled in anchor bolts can be used instead. Proper anchorage design is critical to the successful employment of any motion restraining device. Use of an Integral Vibration Isolation and Snubbing Device (ISOLATOR RESTRAINT) simplifies installation with a minimum quantity of devices, places snubbing loads at the most desirable locations, and reduces pullout loads on anchors by utilizing the equipment weight for minimal anchorage difficulties.

The design team will generally find the best route to qualification by having the motion restraint system designed by the professional design staff of the manufacturer. The individual motion restraint manufacturers are equipped to solve the installation problem with minimal input from the design team. Required information includes:

- Equipment data and geometry.
- Floor motion criteria
- Response spectrums (or other dynamic criteria).
- Applicable code requirements.

SYSTEM SEISMIC CATEGORY

- "A" critical system.

SYSTEM FOUND IN

- All facilities with resiliently supported equipment.

Motion Restraint Systems

All-Directional Snubbers

All-directional snubbers are generally cylindrical and each snubber provides for equipment motion in all three orthogonal axes. They can be installed alongside or beneath equipment. All directional snubbers are generally installed on two sides of the reciprocating equipment adjacent to the vibration isolators.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment.

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Design team judgment.
  - Select motion restraint manufacturer.
  - Refer to professional motion restraint manufacturer for selection of suitable restraint type and installation specifications.

REFERENCE FIGURES FOR INSTALLATION DETAILS

- 4.78, 4.79, 4.80, 4.81, 4.86

RELATIVE DEGREE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Moderate to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Equipment dislocation
- Severed supply lines.
- Equipment failure

Motion Restraint Systems

Isolator Restraints

Isolator restraints are integral vibration isolators and motion restraints that have been combined into a single package. These isolators are easy to examine and maintain

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Design team judgment.
  - Select motion restraint manufacturer.
  - Refer to professional motion restraint manufacturer for selection of suitable restraint type and installation specifications.

REFERENCE FIGURES FOR INSTALLATION DETAILS

- 4.78, 4.79, 4.80, 4.81, 4.83, 4.84, 4.85.

RELATIVE DEGREE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Moderate to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Equipment dislocation.
- Severed supply lines.
- Equipment failure.

Motion Restraint Systems

Lockout Devices

Lockout devices are generally pneumatically operated and restrain equipment that has been resiliently mounted from undergoing sympathetic vibrations that may result from equipment/building–isolation interactions. When a seismic sensing device on the motion restraint "feels" building motions greater than anticipated under normal operation, the lockout is employed. Rams that prevent further motion of the equipment are then inserted into receiving cups on the equipment skid. Once tripped, lockout devices must be manually reset.

EQUIPMENT SEISMIC CATEGORY

- "A" critical equipment

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Design team judgment.
  - Select motion restraint manufacturer
  - Refer to professional motion restraint manufacturer for selection of suitable restraint type and installation specifications.

REFERENCE FIGURES FOR INSTALLATION DETAILS

- 4.39, 4.78, 4.79, 4.80, 4.81

RELATIVE DEGREE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Moderate to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Equipment dislocation
- Severed supply lines.
- Equipment failure

Motion Restraint Systems

Snubbers, Angle Stops

For selected pieces of noncritical and inexpensive reciprocating equipment, the design team may wish to design its own snubbers. The most common method uses angle stops with rubber inertia pads. Care must be taken to avoid creating shock loads that can sever bolt heads, damage the equipment itself, or break the bond between the concrete and anchor bolts. Anchor bolt holes in the base must be round and generally the same size as the anchor bolt rather than oblong.

EQUIPMENT SEISMIC CATEGORY

- "B" support equipment

SEISMIC SPECIFICATION

- SDS-1.

SEISMIC QUALIFICATION APPROACH

- Design team judgment.
  - Make decision for in-house design of snubbers.
- Dynamic analysis.
  - Determine shock loads.
  - Determine spring-mass response (equipment displacements, etc.).
  - Determine anchorage characteristics.
  - Determine correct tolerances.

REFERENCE FIGURES FOR INSTALLATION DETAILS

- 4.78, 4.79, 4.80, 4.81, 4.82.

RELATIVE DEGREE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Moderate to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Equipment dislocation.
- Severed supply lines.
- Equipment failure.

Piping Systems

Although much of the piping within a facility is not critical in itself, ruptures at an inappropriate place and time can lead to the failure of other critical equipment items; for example, a water line failure that allows the emergency power supply room to flood, thus shutting down facility power. The basic philosophy behind qualification of piping systems is to keep the line suspended and to keep it from deflecting so much that it is likely to rupture. Bracing and flexible connections along with separation of the pipe run from the building structure/pipe interface (i.e., where a pipe passes through a wall) significantly reduce piping system failures. Obviously, for critical supply lines or where a failure of a noncritical line is likely to affect the operation of an adjacent piece of equipment in a higher seismic category, the pipe run must be "tuned" so that its natural frequency does not fall within the frequency generated by the earthquake.

SYSTEM SEISMIC CATEGORY

- "B" support system.

SYSTEM FOUND IN

- All facilities.

Piping Systems

Pipe at Seismic Joints

Piping at seismic joints must be capable of displacement in three orthogonal axes simultaneously through the use of flexible connections or ball joints. The inability of the pipe to move with the building would otherwise result in a likelihood of pipe failure.

EQUIPMENT SEISMIC CATEGORY

- Varies.

SEISMIC SPECIFICATION

- SDS-1 or SDS-2.

SEISMIC QUALIFICATION APPROACH

- Design team judgment.
- Dynamic analysis
- Pipe flex computer programs are available

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.93.

RELATIVE DEGREE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Minor to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Severed pipe
- Flooding
- Sanitation problems.
- Steam escape.

Piping Systems

Pipe Hangers, Lateral Braced Horizontal Pipe

Unbraced horizontal pipe is subject to pipe sway, which can transmit high loads to fixed flanges. Lateral bracing (Figure 3.127) can reduce the potential for this type of failure. Compression posts prevent vertical pipe motions.

EQUIPMENT SEISMIC CATEGORY

- Varies.

SEISMIC SPECIFICATION

- SDS-1 or SDS-2.

SEISMIC QUALIFICATION APPROACH

- Design team judgment
- Dynamic analysis.
- Pipe flex computer programs are available

REFERENCE FIGURES FOR INSTALLATION DETAILS

- 4.89, 4.95.

RELATIVE DEGREE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Minor to major.

MOST LIKELY TYPE OR CONSEQUENCE OF DAMAGE FOR INADEQUATELY PROTECTED EQUIPMENT

- Severed pipe
- Flooding
- Sanitation problems.
- Steam escape.

REFERENCE FIGURES FOR EXAMPLES OF DAMAGED EQUIPMENT

- 3.182, 3.183.

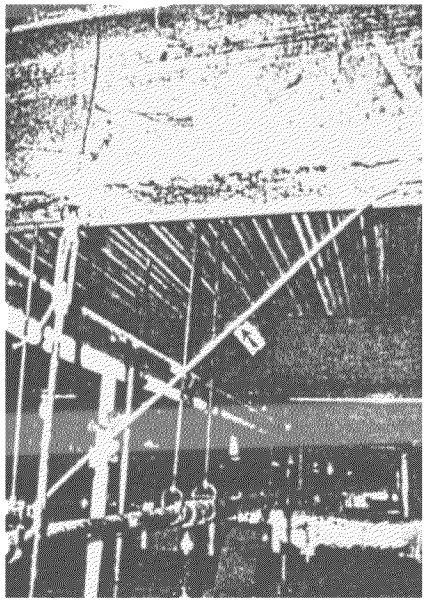

FIGURE 3.127. Horizontal pipe with hangers and lateral bracing

Piping Systems

Pipe Hangers, Longitudinal Braced Horizontal Pipe

Pipe that is unbraced in the longitudinal direction is subject to axial loads at fixed points that may lead to ruptures. Compression posts prevent vertical pipe motions.

EQUIPMENT SEISMIC CATEGORY

- Varies.

SEISMIC SPECIFICATION

- SDS-1 or SDS-2

SEISMIC QUALIFICATION APPROACH

- Design team judgment
- Dynamic analysis.
- Pipe flex computer programs are available.

REFERENCE FIGURE FOR INSTALLATION DETAILS

- 4.90