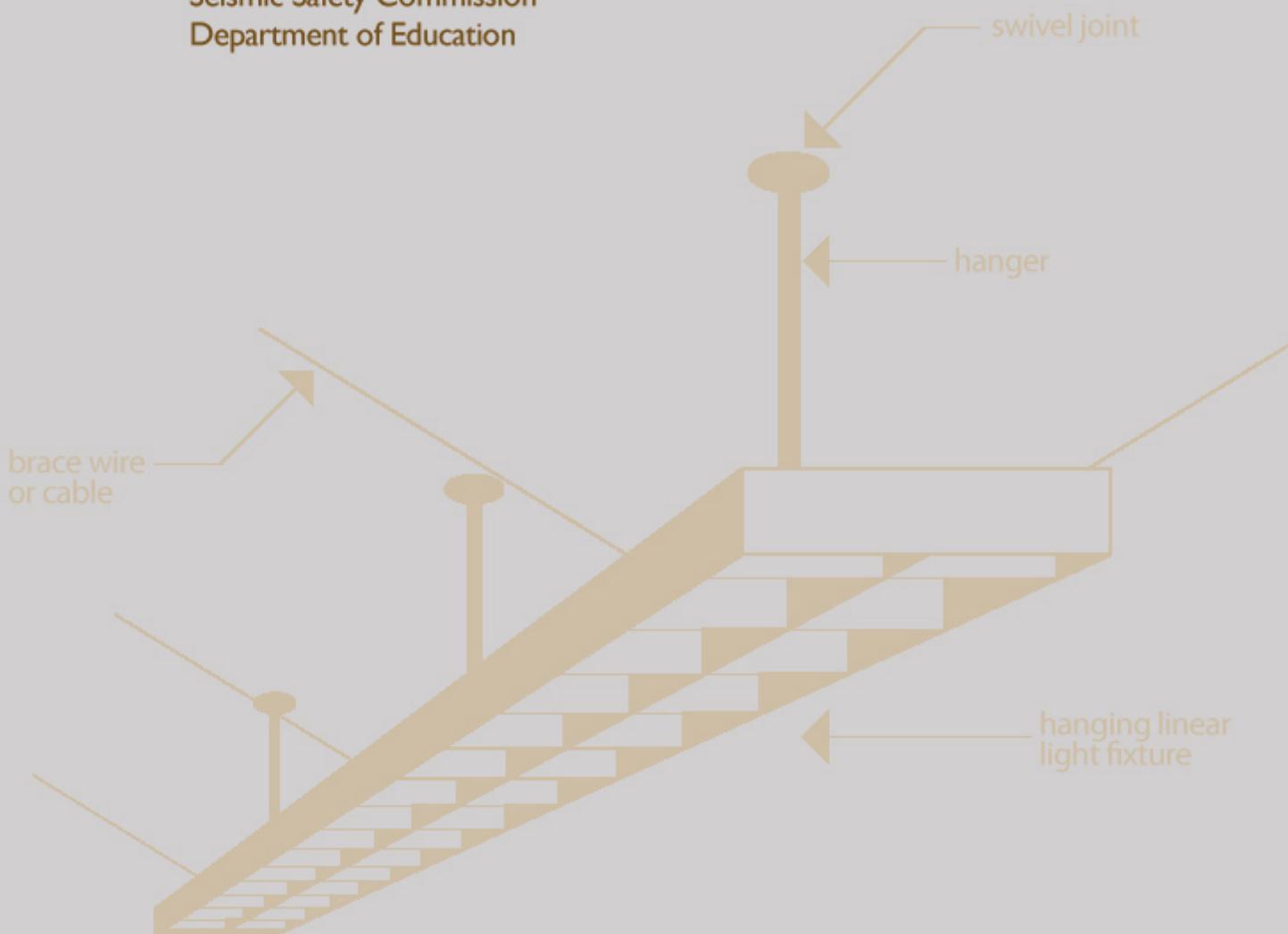


GUIDE AND CHECKLIST FOR

NONSTRUCTURAL EARTHQUAKE HAZARDS IN CALIFORNIA SCHOOLS

A Project of: California Emergency Management Agency (Cal EMA)
Department of General Services (DGS), Division of the State Architect
Seismic Safety Commission
Department of Education



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GUIDE AND CHECKLIST FOR
NONSTRUCTURAL
EARTHQUAKE HAZARDS

IN CALIFORNIA SCHOOLS

Edmund G. Brown, Jr.

Governor

A Project of: California Emergency Management Agency
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January 2011

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Acknowledgements and Disclaimer

The project was originally authorized by Government Code Section 8587.7 (SB 1122 Alarcon, Statutes of 1999) as part of the overall emergency preparedness efforts authorized by the California Emergency Services Act. Participating agencies included Cal EMA (then called the Governor's Office of Emergency Services), Department of General Services-Division of State Architect, the California Seismic Safety Commission, and the Department of Education.

This revision was funded, in part, under a grant from FEMA's Grant Program Directorate, U.S. Department of Homeland Security. Points of view or opinions expressed in this document are those of the authors and do not necessarily represent the official position or policies of FEMA's Grant Programs Directorate or the U.S. Department of Homeland Security.

The recommendations included in this document are intended to reduce seismic hazards associated with the nonstructural components of school buildings, including, but not limited to mechanical systems, ceiling systems, partitions, light fixtures, furnishings, and other building contents. At this time, earthquake engineering is not an exact science and cannot accurately predict the performance of nonstructural elements or guarantee adequate earthquake protection if the guidelines in this publication are followed.

This publication does not address risks associated with the failure of structural elements of school buildings, such as the collapse of walls, columns or roof systems. The recommendations contained herein do not guarantee the safety of any individual structure or facility during an earthquake and should be interpreted and used in a manner consistent with the overall unique safety requirements of each school facility.

Expertise of qualified California licensed design professionals is recommended to increase the probability that intended levels of earthquake protection will be achieved. Liability for any losses that may occur in an earthquake or as a result of using this publication is specifically disclaimed. The State of California specifically disclaims liability for any injury, death, or property damage that may occur during or after an earthquake, or as a result of the use of this publication.

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Introduction

This publication identifies potential earthquake hazards associated with nonstructural components of school buildings, and provides recommendations for mitigating those hazards. Nonstructural components include furnishings and equipment, electrical and mechanical fixtures, and architectural features such as suspended ceilings, partitions, cabinets and shelves. In general, nonstructural components and building contents become hazards when they slide, break, fall, or tip over during an earthquake. Securing the Nonstructural components and building contents improves safety and security of the school facility during an earthquake emergency by:

- Reducing the potential for fatalities and injuries.
- Helping to maintain safe and clear exit ways for evacuation and to access the building.
- Reducing the potential for chemical spills, fires and gas leaks.
- Improving the probability of using the school facility as a shelter following an earthquake.

We had bar ceilings and hanging lights come down. We saw classroom exits blocked by falling cabinets and shelves. In analyzing our damage, it was easy to see what nonstructural mitigation could mean to life-safety and to future costs. We replaced all pendant lighting fixtures and rebuilt T-bar ceilings; book cases, cabinets, and computers were secured. We now regularly inspect every classroom for unsecured items that could be a hazard during an earthquake - just one of the valuable lessons from 1994.

*Bob Spears, Director of Emergency Management
Los Angeles Unified School District
regarding the 1994 Northridge Earthquake*

One of the chilling sights were the overhead exterior soffits lying on the walkways outside the classrooms. We were fortunate it occurred on Easter Sunday - what if school had been in session? We are entrusted with both the care and education of children. Student safety is as important as student achievement. Now, we constantly pose the question: Are we prepared? Are we doing everything we can?

*Christina Luna, Superintendent
Calexico Unified School District
regarding the 2010 Sierra El Mayor Earthquake*

We had done some preparation. We had attached all cabinets and shelves to the walls with angle brackets into studs so most of them withstood the quake quite well...it was only the rooms where they had not been attached or they were in the center where they fell over. Cabinets or shelves taller than about three feet fell over.

*Kenneth Simpkins, Superintendent
Loma Prieta Joint Elementary School District
regarding the 1989 Loma Prieta Earthquake*

Using this publication

The nonstructural components and building contents identified in this publication are listed in one of the following three sections:

1. **Ceiling and Overhead** *(Page 5 to 17)*
2. **Walls and Wall-Mounted** *(Page 19 to 28)*
3. **Furniture and Equipment** *(Page 29 to 49)*

Within each section, an information sheet is provided for each nonstructural component or building content item. Each information sheet provides:

- Description of the item
- A description of the potentially hazardous condition
- Recommendations to reduce the hazard

In some cases, the information sheet will specify that a qualified California licensed architect or engineer must be consulted in order to properly assess and mitigate an identified hazard.

An **Earthquake Hazard Checklist** form is also provided at the back of this publication to assist district staff in conducting a nonstructural hazards survey. One form can be completed for each room within a school building. It is recommended that all buildings on a school campus be surveyed. The form may be photocopied.

Classroom safety may be improved significantly by completing a number of “quick action items” prior to completing a formal inventory. The following are suggested quick action items:

- Store heavy items on lower shelves (below the height of occupants). Do not place heavy items or full boxes on tall furniture.
- Secure hanging plants or hanging displays with closed hook hangers.
- Place tall file cabinets and shelving (over 4 feet) in low occupancy areas (such as a closet).
- Secure desktop equipment and displays that could fall and injure occupants.

A resources/references list is provided on pages 50 and 51. This document, as well as additional information and resources can be found at <http://www.calema.ca.gov/PlanningandPreparedness/Pages/Schools.aspx>

Light Fixtures – Hanging / Pendant

Single fixtures or linear light fixtures that are suspended below the ceiling must have a safety cable, and the fixture must be restrained against swinging unless there is adequate clearance to other objects. Light fixture luminaries, lenses, or diffusers must be fastened securely to the fixture.

Recessed Light Fixtures at Suspended Ceiling

Fluorescent light fixtures installed in a suspended grid ceiling system must have wires connecting the fixture to the structure above. Luminaries, lenses, or diffusers must be fastened securely to the fixture.

Recessed HVAC Registers at Suspended Ceiling

Heating, Ventilation, and Air Conditioning (HVAC) registers installed in a suspended grid ceiling must have wires connecting the fixture to the structure above. HVAC grills (air vents) must be securely fastened to the fixture.

Suspended Ceilings (metal grid with lay in acoustical panels)

Suspended ceilings in large rooms must have diagonal bracing wires within the attic space, connecting the metal grid to the structure above. One set of four brace wires should be spaced 12 feet on center each way.

Hanging Displays & Plants

Hanging plants, mobiles, or displays must have closed eye-hooks at each end of the hanger, and must be able to swing freely at least 45° in any direction without striking other objects (i.e. wall, light fixtures).

Suspended Space Heaters / Air Conditioning (AC) Units

Space heaters suspended from a ceiling or roof must be braced to resist lateral movement, and should have flexible gas connections to the gas service piping.

Decorative Ceiling / Lattice Work

Decorative or sound-absorbing ceiling panels and latticework must be securely attached to the ceiling framing, or if suspended below a supporting ceiling or roof, must be braced to the supporting structure.

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Conduits / Piping

Electrical conduit, gas, plumbing, and fire sprinkler piping, and conduit/pipe trapezes are typically located above ceilings. Large conduits/pipes and trapezes, if suspended from the roof or floor structure above, must be braced to the roof or floor structure to resist movement.

Ductwork

HVAC ducts are typically located above ceilings. Large ducts, if suspended from the roof or floor structure above, must be braced to the roof or floor structure to resist movement.

Lath & Plaster Soffit (exterior)

Plaster soffits (typically at the underside of exterior overhangs and entries) that have any evidence of distress, substantial cracking, water intrusion, or separation from the structure should be inspected by a qualified inspector, architect or engineer.

Tile roofing (exterior)

All roof tiles must be secured to the roof structure with two fasteners at each tile, or alternatively may utilize a wire tie system. Unsecured tiles can fall off the roof in an earthquake (check roof at entries/exits).

Unreinforced Masonry Chimney (exterior)

Older buildings (built prior to 1960) may utilize unreinforced and inadequately secured masonry chimneys, projecting above the roof. These should be removed and replaced with an approved metal flue assembly.

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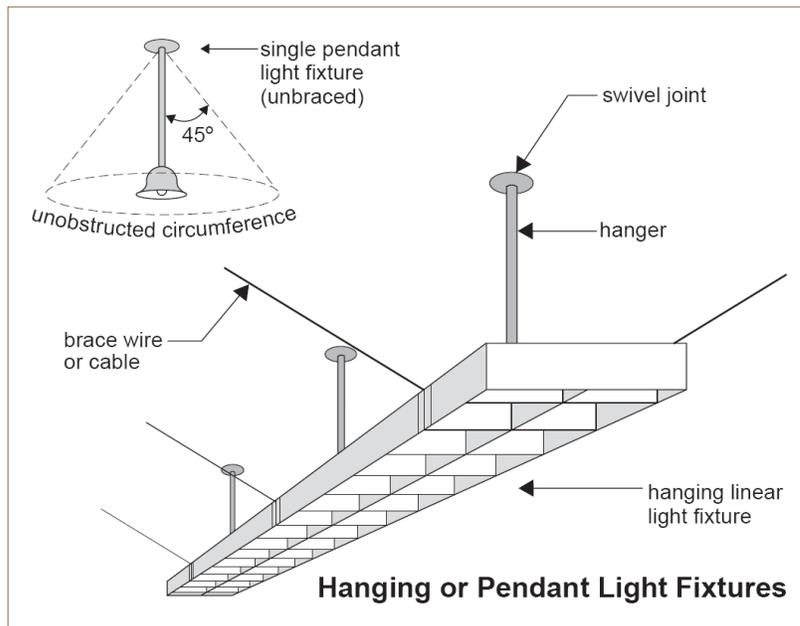
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Hazards

Unsecured light fixtures:

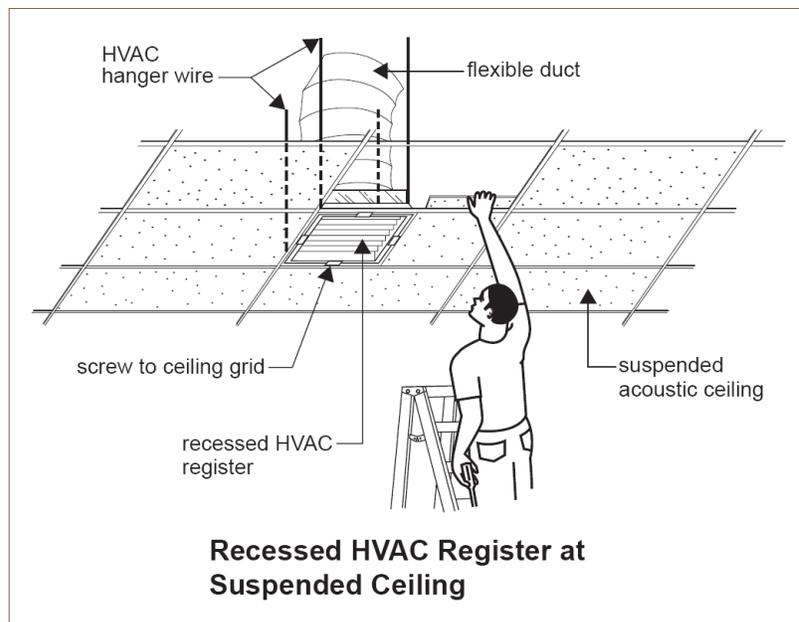
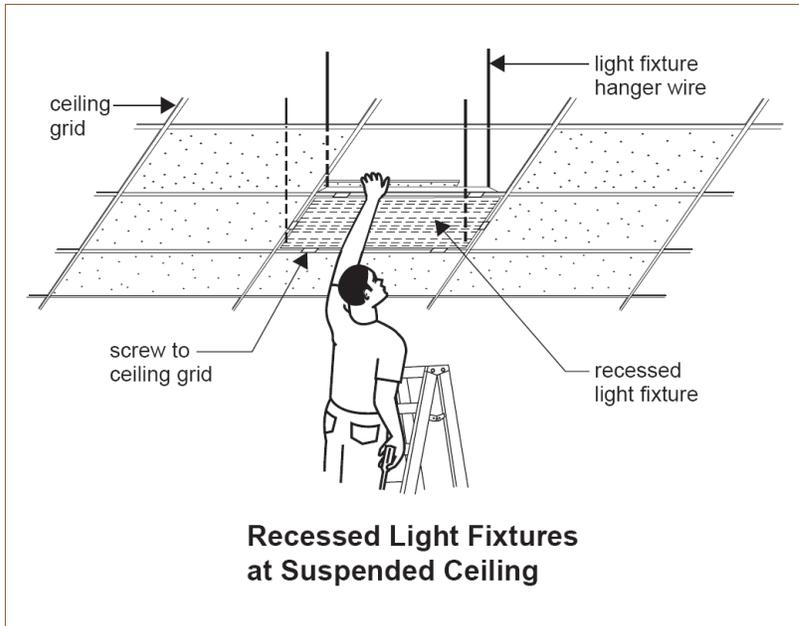
- May fall, striking occupants below, or damaging electrical wiring that could start a fire or electrocute nearby occupants.
- May swing, damaging nearby light fixtures, ducts, or pipes.

Recommendations

- Secure light fixtures to structural floor or beam above with bracing cables or wires. Provide transverse and longitudinal bracing.
- Secure single pendant fixture to structural floor or beam above with four way splay wires.
- As an alternative to bracing, provide clear space around light fixtures to allow them to swing without contracting obstruction in any direction.

Notes

- Light fixture must have swivel joint at top so that they can swing freely in all direction.
- Bracings and hangers for pendant light fixtures should be installed into structural floor slab, beams, or blocking above.



Hazards

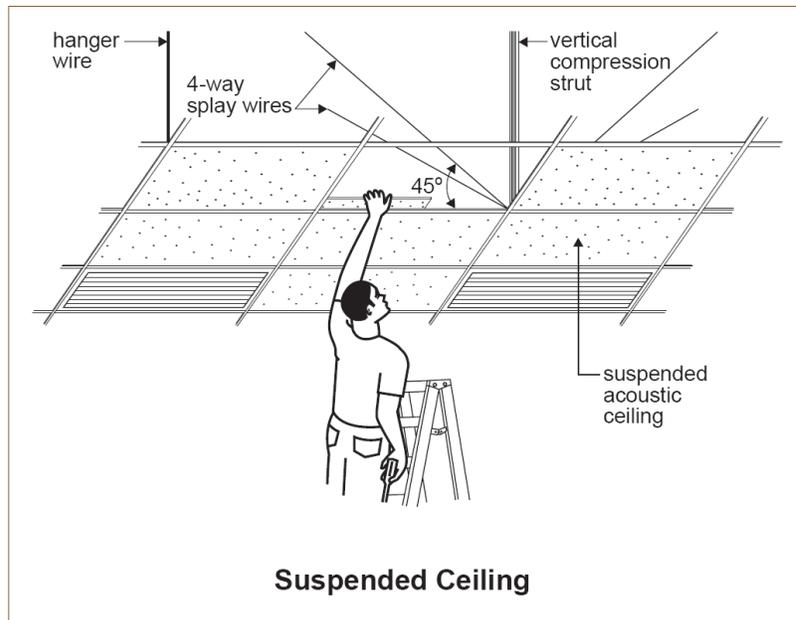
- Unsecured ceiling mounted light fixtures and HVAC registers may fall, striking occupants below or blocking exit ways for evacuation during an emergency.

Recommendations

- Fasten light fixtures, and HVAC registers to the ceiling grid with sheet metal screws on all four sides.
- Install minimum of two hanger wires at diagonal corners of light fixtures or HVAC registers.
- Attach hanger wires to beams or floors above.

Notes

- If light fixtures or HVAC registers weighs 56 lbs. or more, use four hanger wires (one at each corner).
- Use flexible cables to wire light fixtures to existing/new electrical cables in the building.
- Use flexible duct to hook up HVAC registers to existing/new ducts in the building.



Hazards

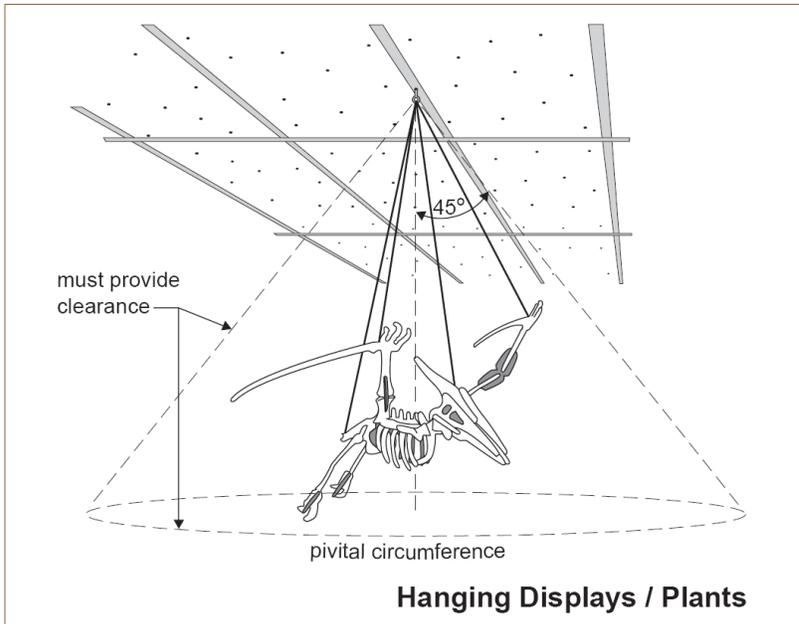
- Unsecured suspended ceiling may fall, striking occupants below or blocking exit ways for evacuation during an emergency.
- Failed suspended ceiling system may lead to broken sprinklers resulting in water damage.

Recommendations

- Provide 4-way bracing wires and compression struts (see illustration).

Notes

- Provide a set of 4-way bracing wires for every 12 feet x 12 feet area.
- Provide a compression strut at each bracing wire location.
- Suspended acoustical ceiling must be intermediate or heavy duty rated.



Hazards

Hanging display:

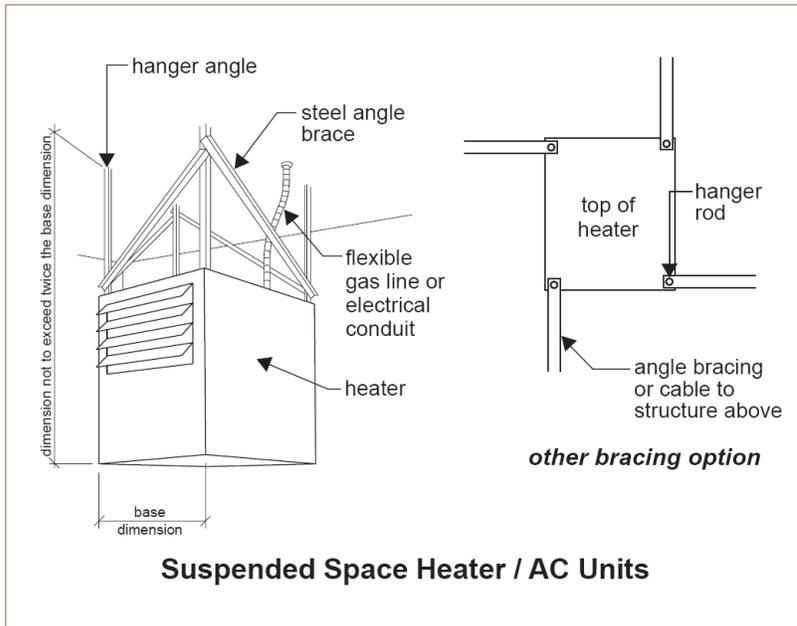
- May fall, striking occupants below or blocking exit ways for evacuation during an emergency.
- May sway, striking nearby objects and causing them to fall.

Recommendations

- Hang displays from beams or floor above. Do not hang from suspended ceilings.
- Provide adequate clearance around the display, so that it could sway without contacting obstructions.

Notes

- Relocate display away from doors or exits.



Hazards

Unsecured suspended space heaters/AC units:

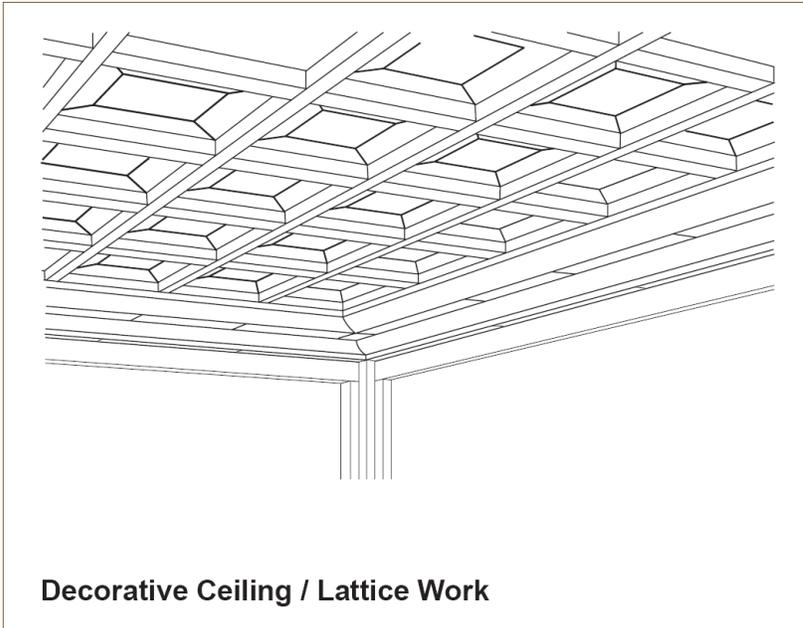
- May fall, striking occupants below, damaging electrical wires that may cause electrical shocks and fire, or blocking doors and exit ways during an emergency.
- May sway, damaging nearby pipes, ducts, ceilings, walls, or conduits.

Recommendations

- Provide diagonal braces that are attached to the equipment at four corners (see illustration).
- Provide diagonal braces that are attached to hanger rods (see illustration).

Notes

- Space heaters/AC units must be suspended by hanger rods or steel angles.
- Space heaters/AC units must have flexible pipes or conduits connected to them.
- Relocate space heaters/AC units away from doors, and exit ways.
- Consult a qualified architect or engineer to determine the bracing requirements.



Hazards

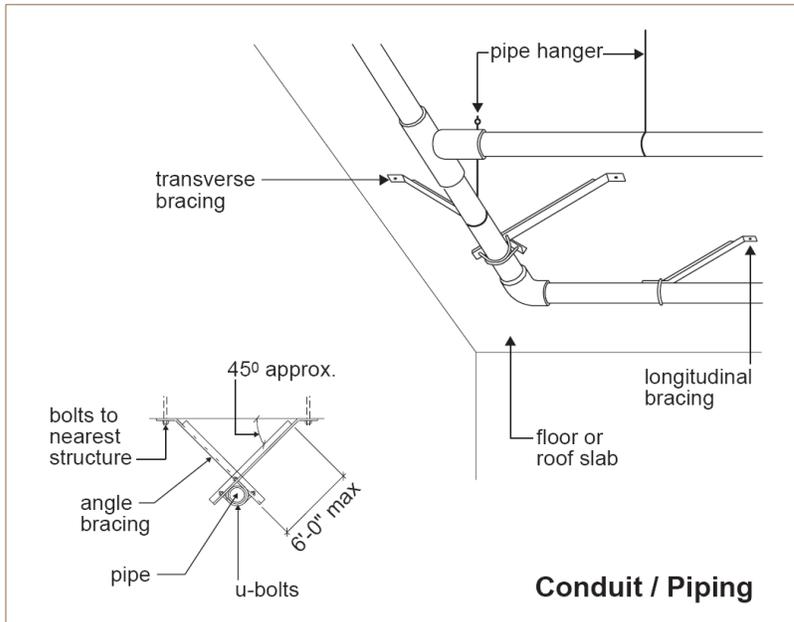
- Unsecured decorative ceiling/lattice work may fall, striking occupants below or blocking hallways and exit ways during an emergency.

Recommendations

- Brace decorative ceiling/lattice work with splay wires similar to suspended ceilings (see page 9).

Notes

- Decorative ceiling/lattice should have compression struts for splay wires.



Conduit / Piping

Hazards

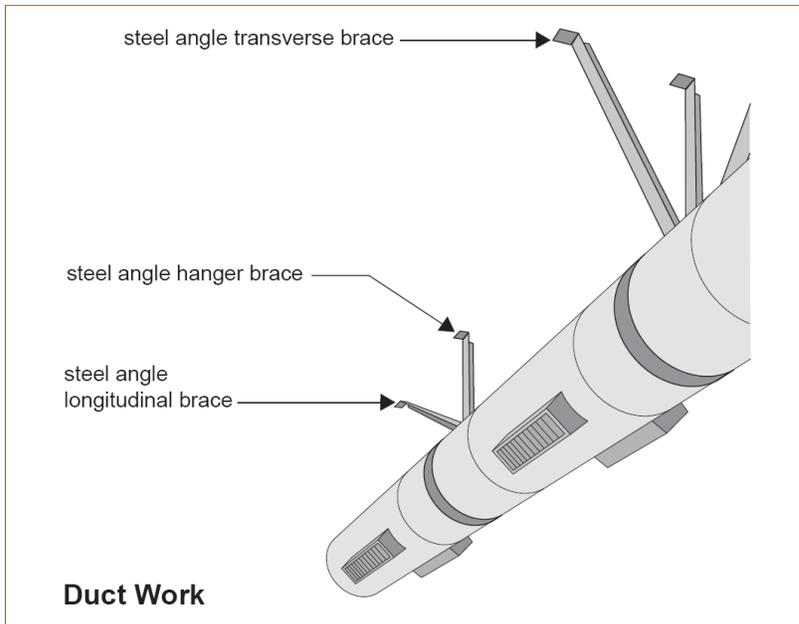
- Pipe may fall, striking occupants below.
- Gas pipe may break, causing fire or explosion.
- Pressure pipe may break, becoming a live “whip” that could injure nearby occupants.
- Steam pipe may break, burning occupants below or nearby.

Recommendations

- Secure pipe with transverse and longitudinal bracing.

Notes

- Design of transverse bracing and longitudinal bracing should be determined by a qualified architect, structural engineer, or mechanical engineer.
- Use pipe fittings to attach bracing to pipe.
- Attach bracing to structural floor beams or blocking above. Do not attach bracing to suspended ceilings.
- Bracing not required for fuel piping less than 1 inch diameter.
- Bracing not required for other piping less than 3 inch diameter if there is enough clearance for the pipes to swing without obstruction. Consult a qualified architect or structural engineer for seismic bracing requirements.
- Bracing not required for piping suspended by individual hangers 12 inches or less in length.
- See “Resources” for more information from the Sheet Metal and Air Conditioning Contractor National Association (SMACNA).



Hazards

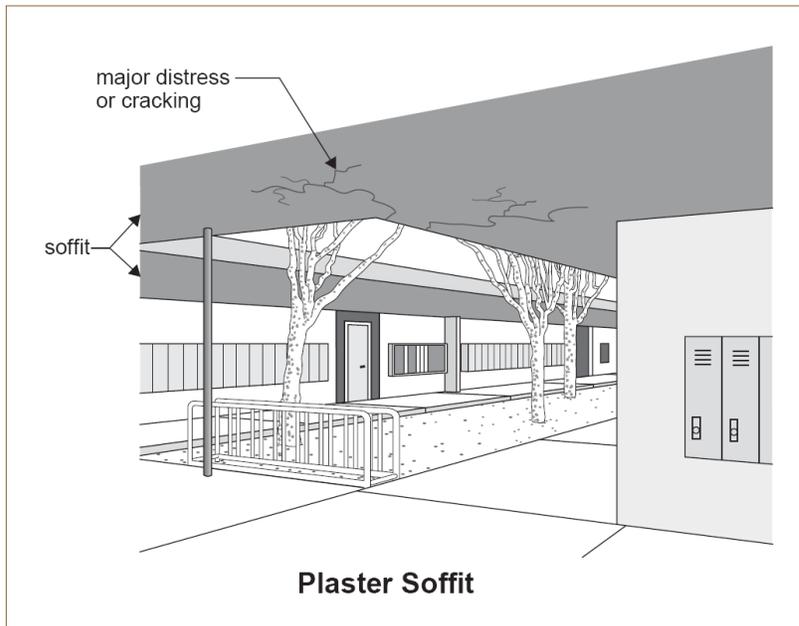
- Unsecured ducts may fall, injuring occupants below.
- Fallen ducts may block exit ways.

Recommendations

- Secure ducts with transverse and longitudinal braces.
- Attach braces to ducts with proper duct fittings.
- Attach braces to structural floors or beams above with concrete drill-in anchor bolts or lag bolts.

Notes

- Design of transverse and longitudinal bracing should be determined by a qualified architect, structural engineer, or mechanical engineer.
- Use concrete drill-in anchor bolts for concrete construction.
- Use lag bolts for wood construction. Lag bolts should be installed in beams or blocking.
- Bracing not required for rectangular ducts when the width (W) and height (H) dimensions in feet are such that $W \times H$ is less than 6 square feet, and round ducts less than 30" in diameter, if there is enough clearance for them to swing without obstruction. Consult a qualified architect or structural engineer for seismic bracing requirements.
- See "Resources" for more information from the Sheet Metal and Air Conditioning Contractor National Association (SMACNA).



Hazards

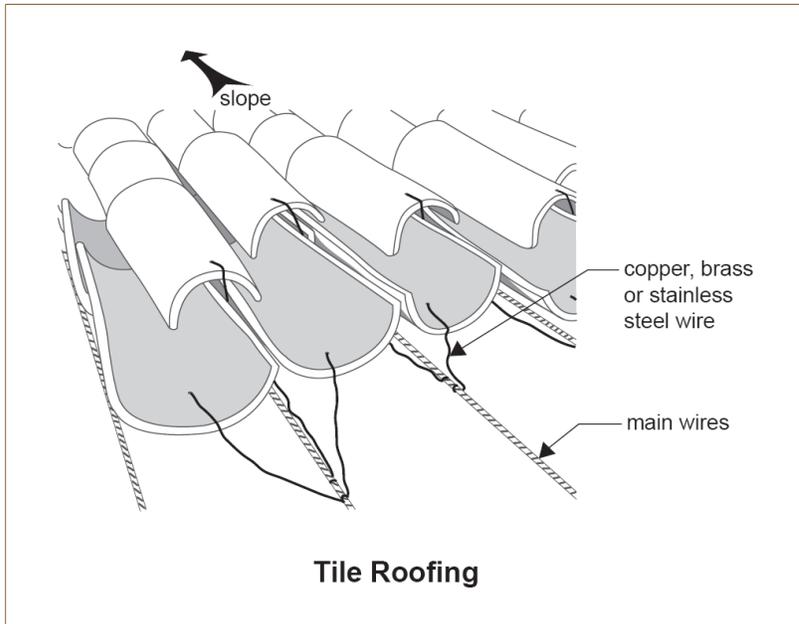
- Plaster that is cracked, deteriorated, or was installed prior to 1978 may collapse; striking occupants below or blocking hallways and exits during an emergency.

Recommendations

- Have the plaster soffit and its connections to the structure above it inspected by a qualified inspector.
- Consult a qualified architect or structural engineer for repair or retrofit as required.

Notes

- Inspect plaster ceiling or soffit if there are large cracks, excessive sagging, or separation from the substrate.
- Look for improper connections of the ceiling soffit to the structure above such as loosely turned wires or tack welds.



Hazards

- Unsecured roof tile may fall, injuring occupants below or blocking hallways and exit ways during an emergency.

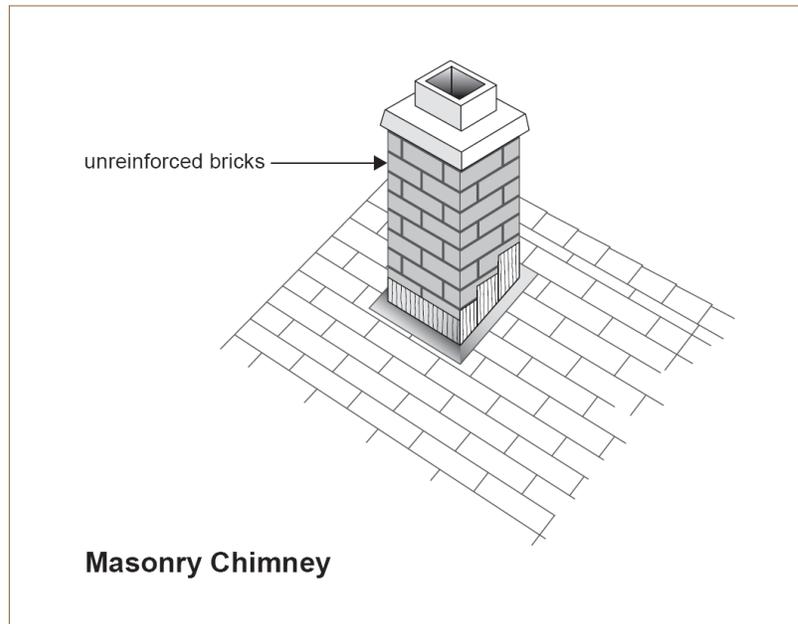
Recommendations

Secure roof tiles with two fasteners per tile, using:

- copper, brass or stainless steel wires or,
- copper, brass or stainless steel nails.

Notes

- Wires must be capable of supporting four times the weight of tiles per California Building Code.
- Consult a qualified architect or structural engineer for seismic bracing requirements.

**Hazards**

- Unreinforced masonry chimney may collapse, striking occupants below or damaging roof and other structural elements supporting the building.

Recommendations

- Remove unreinforced masonry chimneys and replaced with an approved chimney with metal flue.

Notes

- Buildings built before 1960 may have unreinforced masonry chimneys.
- Consult a qualified architect or structural engineer for seismic requirements.

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Shelving

- Shelving frame must be securely fastened to wall framing.
- Shelves must be securely fastened to the frame.
- Shelves must have shelf lips or other means to restrain stored items.
- Chemicals or other hazardous materials stored on shelves must be segregated and secured.
- Heavier items should always be stored at lower level shelving.

Wall-Mounted Cabinets / Lockers / Coat Closets

Wall-mounted cabinets, lockers, or closets must be securely fastened to wall stud. Interior walls on which cabinets are mounted, if located in a room with suspended ceilings, should be checked as noted under “Walls and Partitions” below.

- Cabinet doors should have positive latching device or other means to secure in closed position.
- Shelving within wall-mounted cabinets should be checked per “Shelving” notes above.

Wall-Mounted TV, Video Monitors and Speakers

Wall-mounted TV or video monitors typically utilize a manufactured mounting bracket. The mounting bracket must be fastened to wall stud. TV or video monitors must be secured to the bracket.

Pictures / Wall Decorations / Signs

Pictures or other wall-hung items should utilize closed eye-hook connectors and, except for light objects (less than 5 pounds), the supporting hardware must be connected to wall framing (not only to drywall).

Fire Extinguisher

Wall-mounted hardware for fire extinguishers must be secured to wall studs. The fire extinguisher must be secured to the cabinet or bracket.

Interior Walls

Interior walls in rooms with suspended ceilings (metal grids with lay-in acoustical panels) often terminate just above the ceiling level, and must be braced to the structure above, typically using diagonal stud members (wood or metal) or wires.

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2.

Free-Standing and Cubicle Partitions

Free-standing and cubicle partitions must be adequately braced to prevent horizontal movement at the top of the partition. Bracing is typically provided by connections to intersection partitions or modular furniture. Particular attention should be given to partitions that support shelving or cabinets.

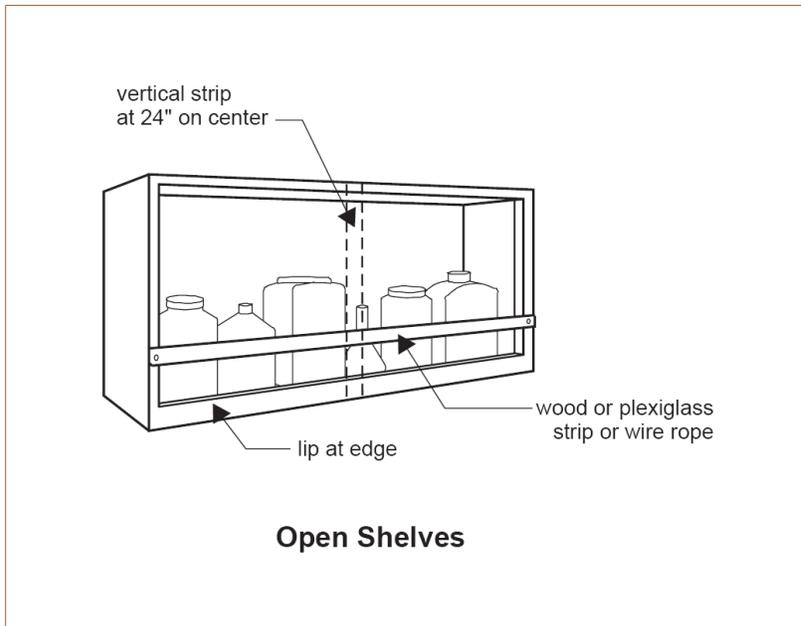
Windows/Entry Glass

Glass adjacent to or within entrance or exit doors must be safety glass (i.e. tempered or laminated). Safety glass can be identified by an etched mark on each pane. Replacement of non-compliant glass with safety glass in these locations is recommended.

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2.



Hazards

Unsecured contents may fall off shelves:

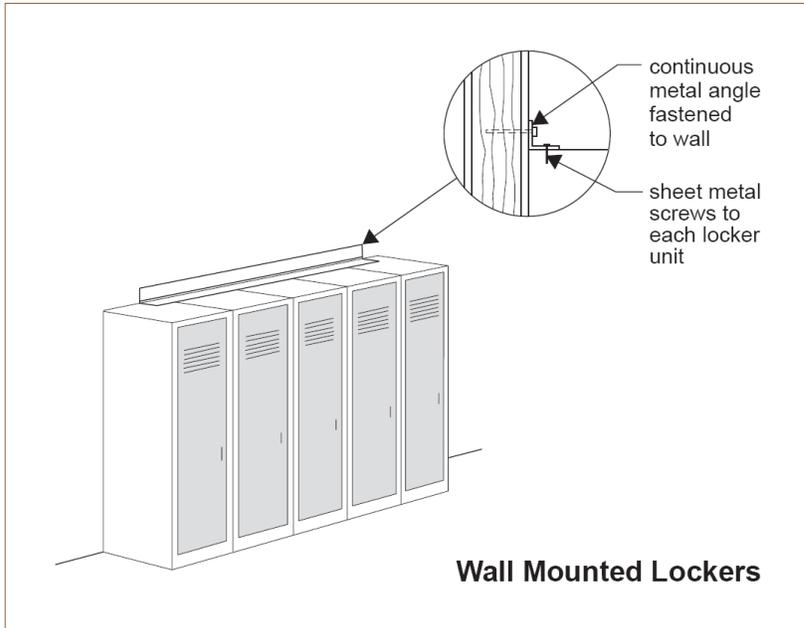
- Striking nearby occupants,
- Spilling dangerous chemicals.

Recommendations

- Install wood or Plexiglas strips across open face of shelves (see illustration).
- Install doors on open shelves.
- Shelves must be secured.
- Install shelf with a lip to prevent objects from falling off the shelf.

Notes

- Relocate heavy items or volatile chemicals to floor mounted cabinets.



Hazards

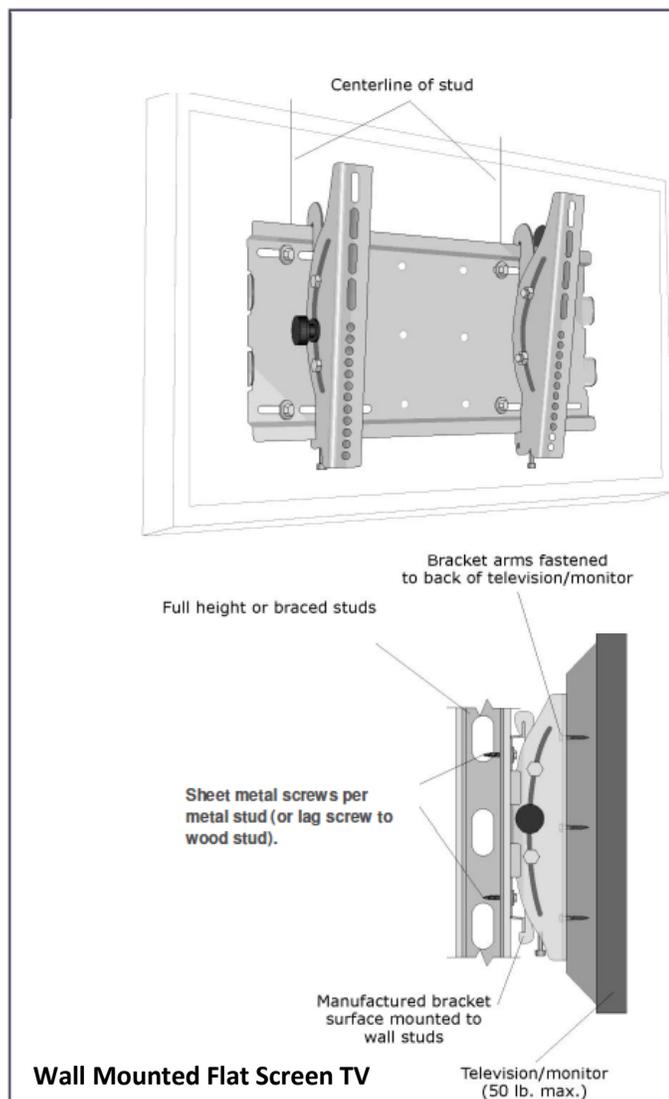
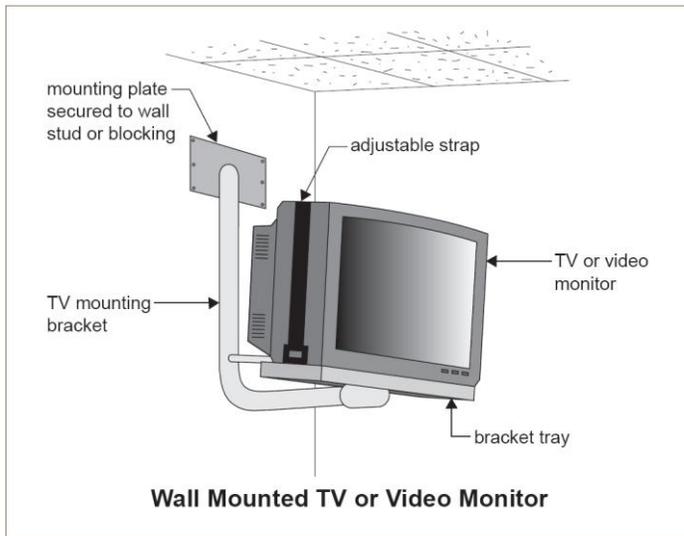
- Unsecured wall mounted cabinets/lockers (shown)/coat closets may fall, striking nearby occupants or blocking hallways and exit ways.

Recommendations

- For single unit, secure each unit to wall studs or blocking with screws.
- For multiple units, fasten each unit to a clip angle with sheet metal screws. Fasten clip angle to wall studs or blocking with screws.

Notes

- Relocate cabinets, lockers, or coat closets away from hallways and exit ways.



Wall-mounted television/monitor bracket (source: FEMA E-74)

Hazards

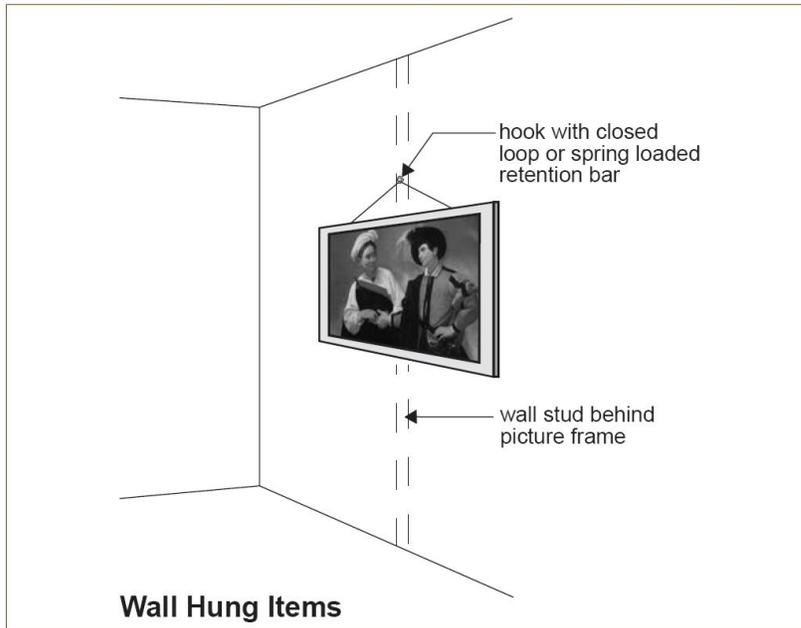
- Unsecured TV, monitors, or speakers may fall off the mounting brackets, striking occupants below or blocking exit ways for evacuation during an emergency.
- A fallen TV or monitor may damage electrical wiring, exposing nearby occupants to electrical shock, causing interruption to electricity or starting a fire.

Recommendations

- Secure TV, monitor, or speaker to mounting brackets with snugly fitted adjustable strap.
- Follow the recommendation provided by the manufacturer for mounting bracket for TVs, video monitors, or speakers.
- Locate TV/monitor mounting brackets away from doors or exit ways.

Notes

- Mounting bracket must be installed per manufacturer's instructions.
- TV, video monitors, or speakers must not exceed the manufacturer's recommended weight limit.
- Mounts for flat screen TV must have hooks, set pins, screws, or bolts to prevent horizontal sliding and upward movement.
- Consider using a pre-approved mounting bracket and installation from the Office of Statewide Health Planning and Development (OSHPD).
- Consult a qualified architect or structural engineer for seismic bracing requirements.



Hazards

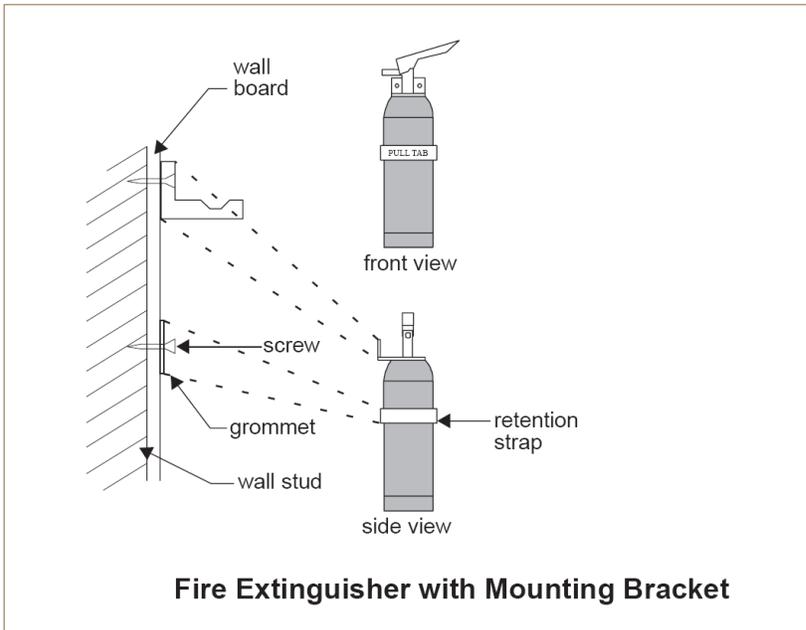
- Unsecured wall hung items such as pictures, decorations or signs may fall, striking nearby occupants or blocking exit ways for evacuation during an emergency.

Recommendations

- Install hook into wall stud. Close hook with pliers after hanging item.
- Alternatively, use hook with spring-back retention bar.

Notes

- Do not hang an item that weighs more than recommended by the hook manufacturer.



Hazards

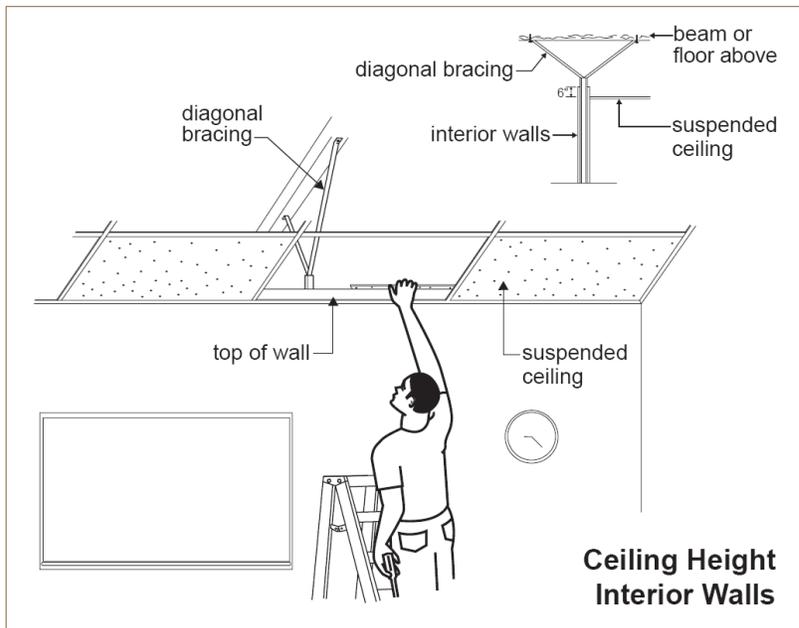
- Unsecured fire extinguisher may fall off wall and damage the shut-off valve or hose, releasing its contents.
- A damaged fire extinguisher may not be functional in an emergency.
- Unsecured fire extinguishers may fall, striking nearby occupants.

Recommendations

- Secure fire extinguisher mounting bracket or cabinet to wall framing.

Notes

- The cabinet must be accessible either through breakable glass or latched door.



Hazards

Unsecured ceiling-height wall may fall:

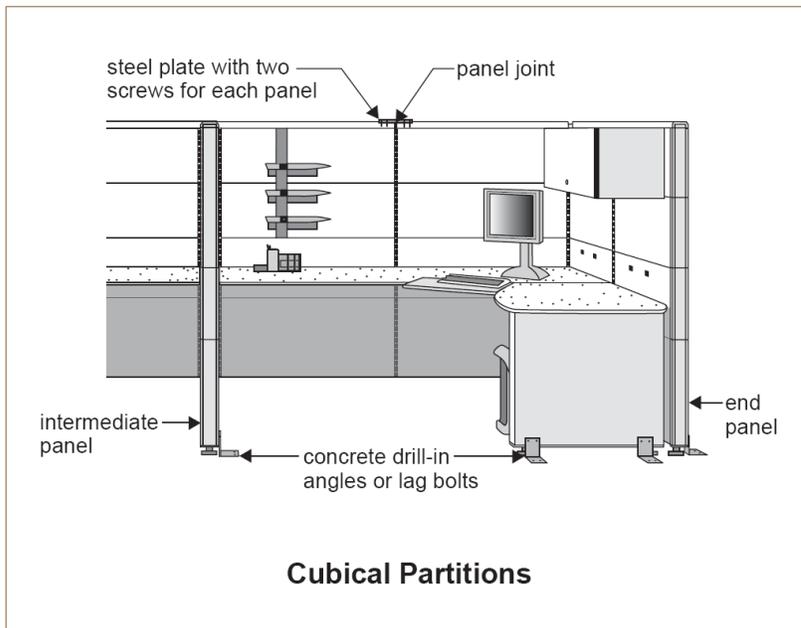
- Striking nearby occupants,
- Blocking exit ways during an emergency,
- Damaging pipes and electrical wiring in wall that may cause flooding, gas leaks, electrical shocks, fire, and interruption of utility services.

Recommendations

- Secure ceiling-height walls with diagonal bracing.

Notes

- Ceiling-height interior walls typically are walls erected to a height about 6" above ceilings.
- These walls usually are not fire-rated.
- Consult a qualified architect or structural engineer before hanging any cabinets or heavy objects on interior walls.
- Consult a qualified architect or structural engineer for seismic requirements.



Hazards

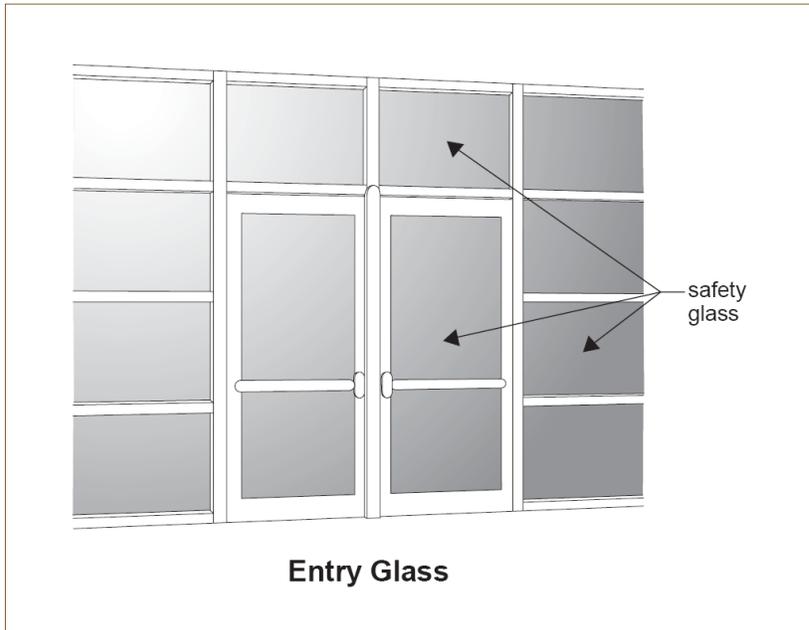
- Unsecured cubical partitions may fall, injuring nearby occupants.
- Fallen cubical partitions may block doors and exit ways.

Recommendations

- Attach a clip angle to each end of each panel. Use a minimum of two fasteners where each clip attaches to panel.
- Secure each clip angle to concrete floor with concrete drill-in anchor bolt, or to wood floor with lag bolt. Lag bolt must be installed into floor joists or blockings. Use a minimum of two bolts where each clip is secured to the floor.

Notes

- Clip angle must be screwed into the metal frame portion of the cubical partition. Do not attach to metal or plastic flashings.
- Maximum distance between intermediate or end panels is 10 feet.
- Panel joint must be rigid.
- If panels were hinged together or joints were not rigid, reinforce the top with steel flat plate across the joint and secure the bottom with clip angle (see illustration).
- Relocate heavy storage from upper shelves or bins.



Hazards

Glass may fall:

- Injuring nearby occupants, or
- Blocking doors and exits during an emergency.

Recommendations

- Replace glass on door and glass surrounding the door with safety glazing.

Notes

- Safety glass has a permanent identification label etched or ceramic fired on the glass and readable from the inside of the building.
- Another name for glass is glazing.

File Cabinets

File cabinets more than 3 feet in height should either be arranged in groups and fastened together, or secured to an adjacent wall in order to prevent overturning. Cabinets must have latching drawers.

Bookcases

Bookcases more than 3 feet in height either should be placed back-to-back and fastened together, or should be secured to a wall. Library bookcases (+6 feet height) require floor or wall anchorage.

Desktop / Countertop Equipment

Desktop or countertop equipment should be secured to the desk, counter, or wall to prevent the equipment from sliding and falling from the desk or counter.

Equipment on Cart (video, projector)

When not in use, carts should have wheels locked, or alternatively, the cart can be tethered to an adjacent wall. Equipment should be secured to the cart.

Display Cases / Art Objects / Potted Plants

Free-standing objects may require restraint to prevent overturning. Heavy or sharp objects placed 3 feet or more above the floor should be restrained. Secure contents within display cases to prevent broken glass.

Aquariums

Free-standing aquariums must be secured to the floor and/or adjacent to wall to prevent overturning. Aquariums that rest on a table, counter, or shelf must be secured to prevent sliding.

Equipment on Wheels / Rollers (e.g. piano, chalkboard)

Free-standing equipment on wheels/rollers should have the wheels/rollers locked to prevent movement, or alternatively, the equipment can be tethered to an adjacent wall.

Office Equipment

Large or heavy office equipment should be restrained to prevent sliding, or located so that it will not block an exit way.

Refrigerators / Vending Machines

Refrigerators, vending machines and similar equipment should be secured to the floor or adjacent wall, unless confined on three sides.

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3.

Shop / Gym Equipment

Free-standing shop or gym equipment should be secured to the floor (and/or wall) to prevent sliding and/or overturning. Weights and heavy tools should be properly stored (secured) when not in use.

Gas Cylinders/Tanks

Compressed gas cylinders, including oxygen and compressed air, must be restrained (tethered to a wall or secured within a cabinet) to prevent overturning.

Gas Piping (shut-off valve & flexible connectors)

Shut-off valves must be provided at the gas service to any laboratory, mechanical or plumbing equipment, and an approved flexible connector should be provided between the shut-off.

Storage Racks

Storage racks must have cross-bracing and must be secured to the floor.

Electrical Equipment (cabinets, switchgear, transformers)

Electrical equipment must be restrained, and is typically anchored at the equipment base to the floor or concrete pad.

Mechanical Equipment (chillers, fans)

Mechanical equipment must be restrained, and is typically anchored at the equipment base to the floor or concrete pad.

Plumbing Equipment (water heater, tanks, pumps)

Plumbing equipment must be restrained, and is typically anchored at the equipment base to the floor, or are braced to an adjacent wall.

Kitchen Equipment (oven, range, hood, refrigerator / freezer, dishwasher)

Kitchen equipment must be restrained, and is typically anchored at the equipment base (legs) to the floor, or are braced to an adjacent wall.

Raised Floors with Computer or Electronic Equipment

Access floor base pedestals should be anchored to the floor slab. Heavy equipment should be anchored to the structural slab below.

Page
41

42

43

44

45

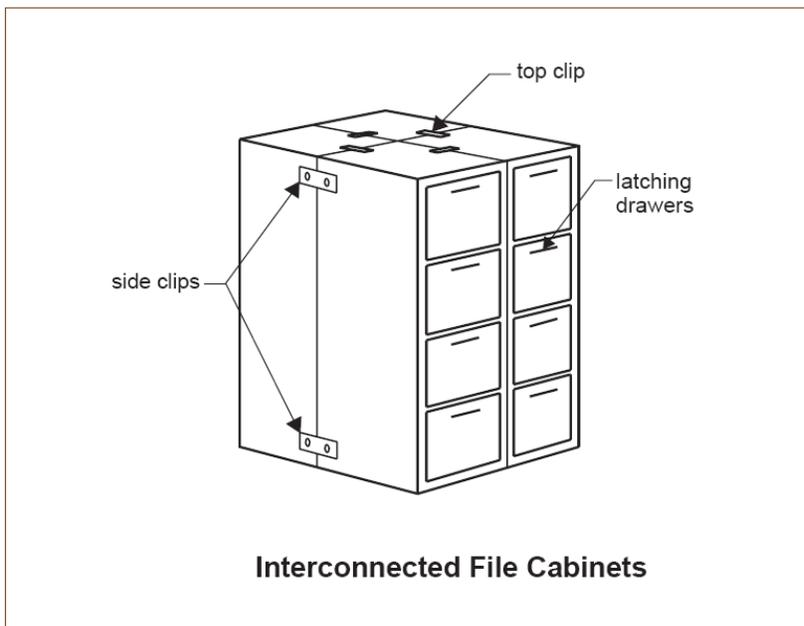
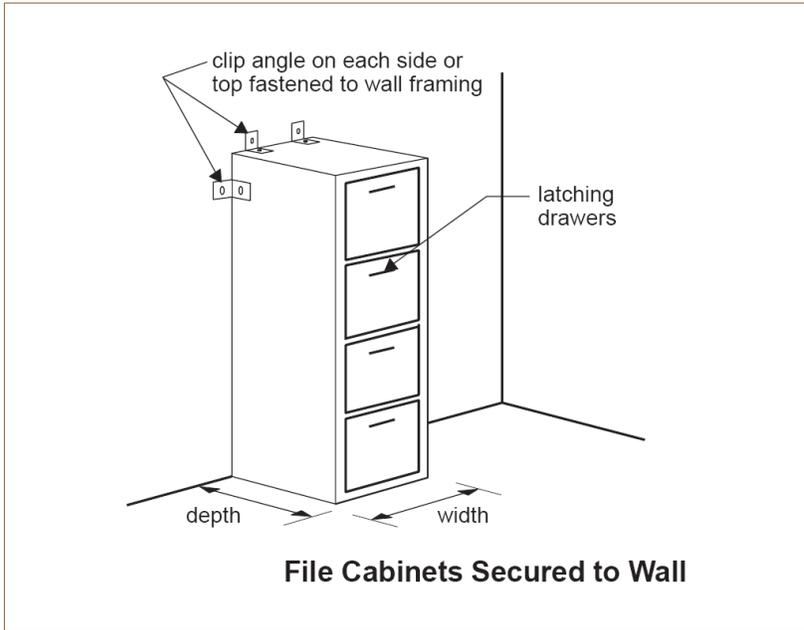
46

47

48

49

3.



Hazards

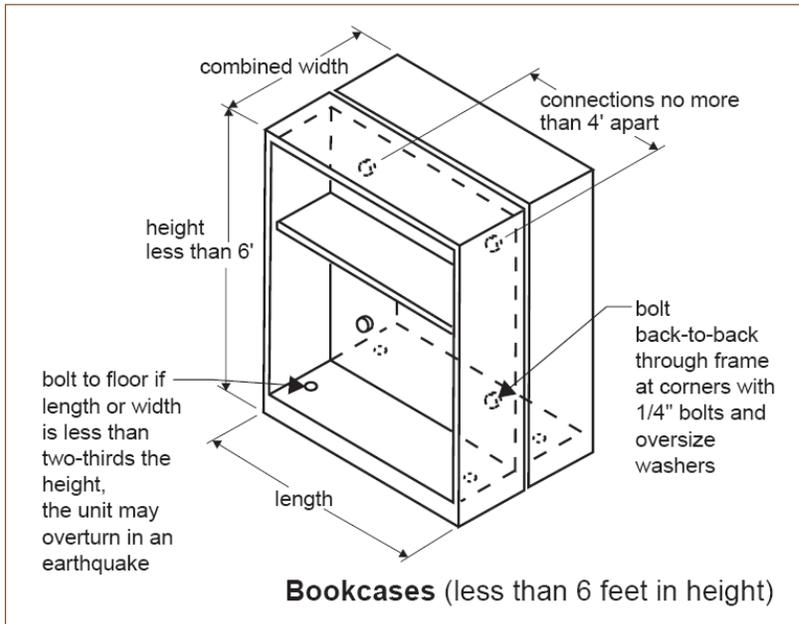
- Unsecured cabinets may fall over during an earthquake.
- Unlatched drawers may open during an earthquake, which may cause the cabinet to fall over.

Recommendations

- When the cabinet depth or width (see illustration) is less than two-thirds the height, the cabinet should be secured to an adjacent wall, or fastened to adjacent cabinets.
- Cabinets should have latching drawers.
- Heavier contents should always be stored in lower drawers of a file cabinet.
- Locate cabinets away from exits and hallways.
- Keep cabinet drawers closed, latched, or locked.

Notes

- Metal clips should be provided for attachments at cabinets and at walls.
- Metal clip attachments at the cabinet should utilize screws or bolts.
- Metal clip attachments at the wall should utilize screws that are properly installed into wall studs or blocking. Do not use toggle bolts (fastened to drywall).



Hazards

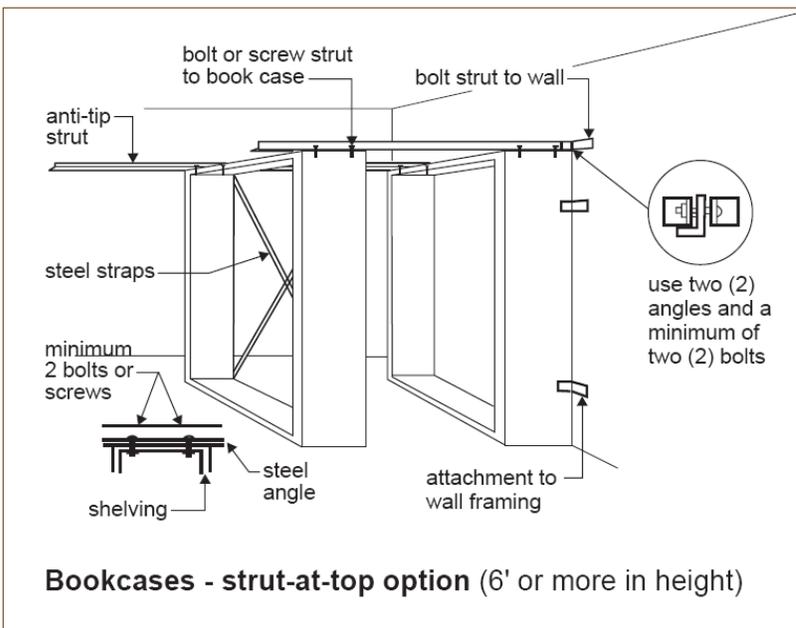
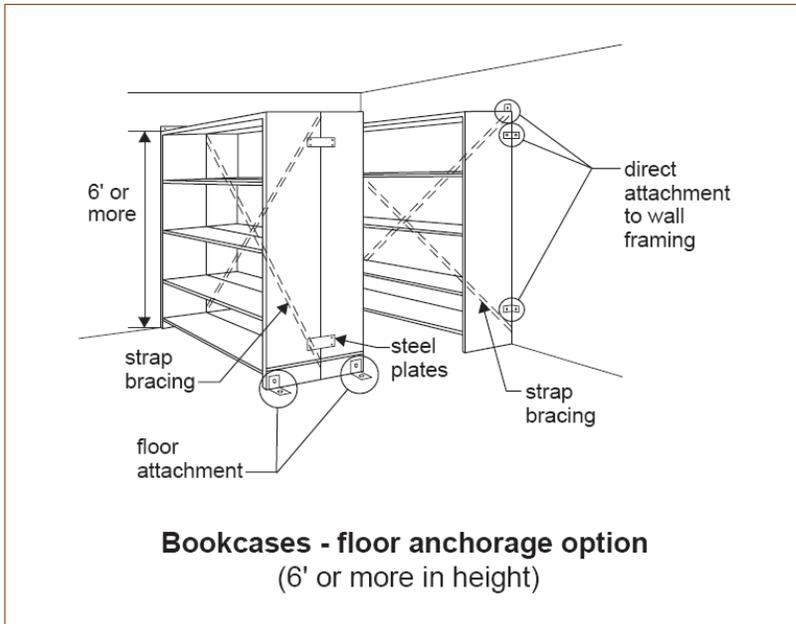
- Unsecured bookcases may fall, striking nearby occupants or blocking doors and exit ways for evacuation during an emergency.

Recommendations

- Connect back-to-back bookcases together with clips and bolts or screws.
- Fasten bookcases to floor if the length or combined width is less than two-thirds the height to prevent tipping over.
- Fasten isolated bookcases to floor or wall.

Notes

- See page 33 for bookcases greater than 6 feet in height.
- Relocate heavy books to lower levels.



Hazards

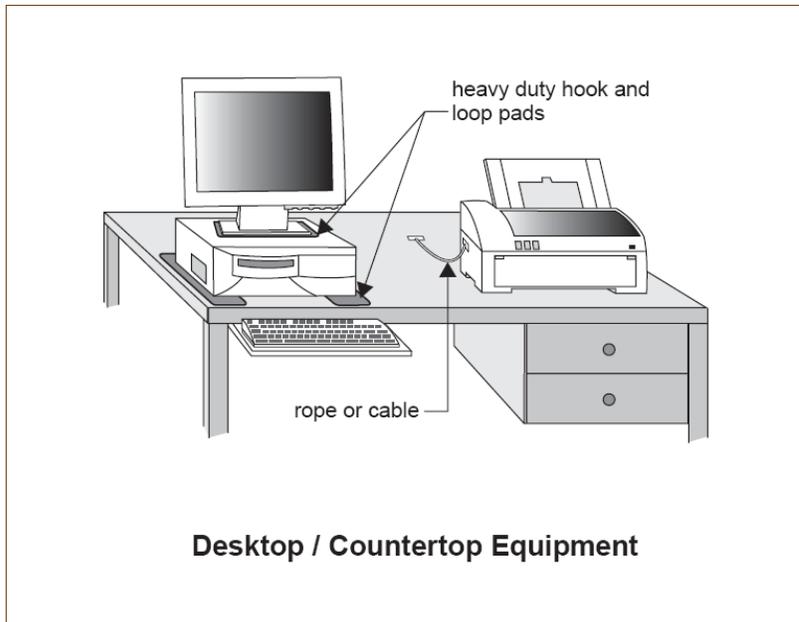
- Unsecured bookshelves may fall, striking nearby occupants or blocking exit ways or doors during an emergency.

Recommendations

- Install cross bracing in back of bookcases. Use cable or metal strap for braces.
- If bookcases were located back-to-back, connect them together with steel plates.
- Secure bookcases to wall or floor using clip angles.
- Alternatively, secure bookcases with anti-tip struts at top.
- For bookcases standing next to a wall, secure them to wall framing with clip angles.

Notes

- Bolt or screw through framing of bookcases.
- Relocate heavy books to lower levels.



Hazards

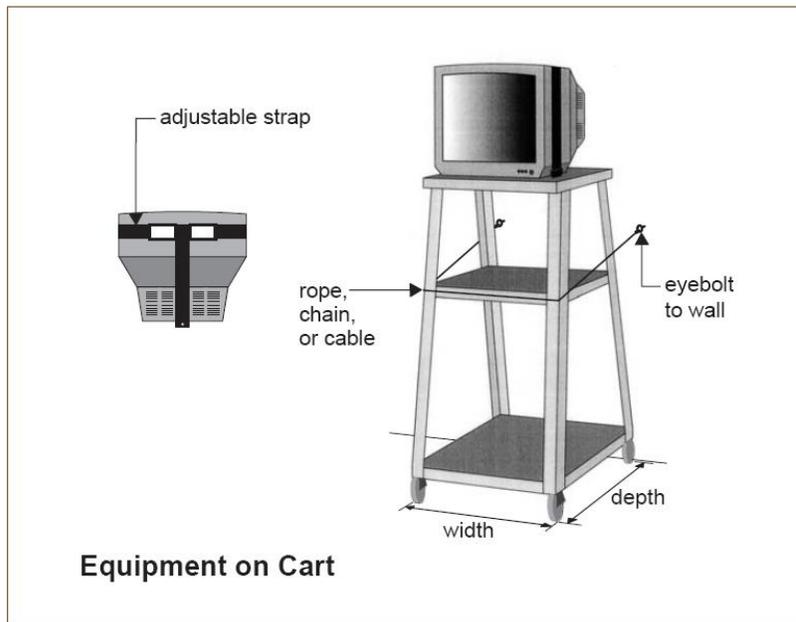
- Unsecured desktop equipment may fall off desk, striking nearby occupants or blocking doors and exit ways.
- Fallen desktop equipment may damage electric wiring, causing power interruption, electrical shock to nearby occupants, or fire.
- Unsecured office equipment may break as it falls, posing a threat to operational recovery.

Recommendations

- Secure with heavy-duty hook-and-loop fasteners. Attach self-adhering hook-and-loop pads to base of desktop equipment case and the mating pads to desktop.
- Secure with cable or rope with self-adhering anchor pads to equipment and desktop.
- Relocate desktop away from doors and exit ways.

Notes

- For heavy countertop equipment such as an ice maker, consult a qualified structural engineer or architect.
- Many vendors supply various types of seismic fastening systems that may be used in lieu of the hook-and-loop system.
- Search the internet for “earthquake safety fasteners” or visit your local hardware store.



Hazards

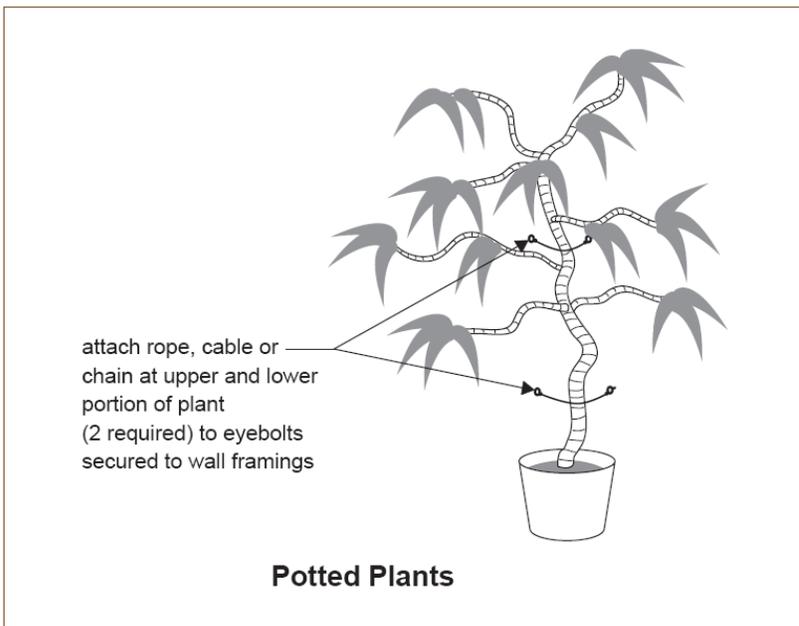
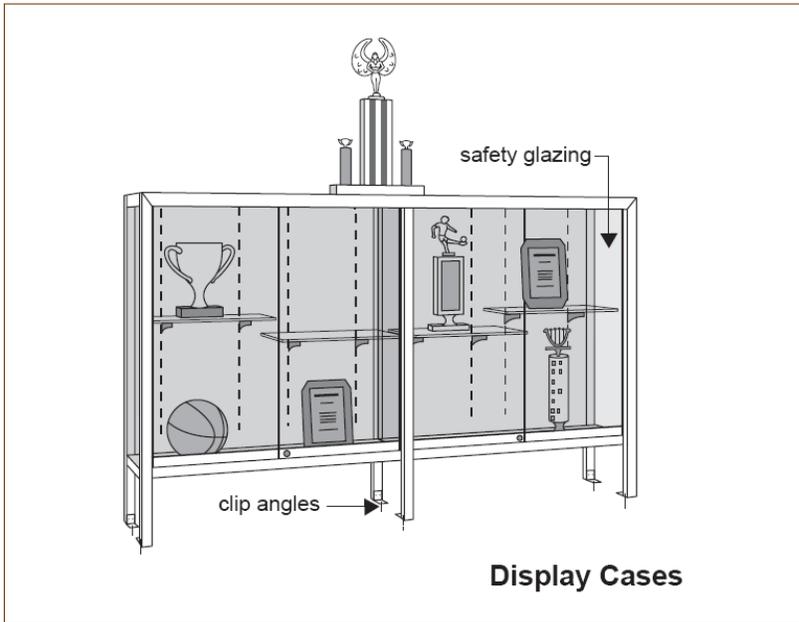
- Equipment may fall off cart or topple cart, striking nearby occupants or blocking doors and exit ways.

Recommendations

- Secure equipment to cart with adjustable straps. Tighten strap to remove any slack.
- Relocate carts away from hallways and doors.

Notes

- Cart should have locking wheels or casters.
- If the height of the cart exceeds two thirds the depth or width of the cart (see illustration), secure the cart to wall with rope, chain, or cable.
- Rope, chain, or cable should be attached to eyebolts or other closed loop fasteners, which should be installed into wall studs or blocking.



Hazards

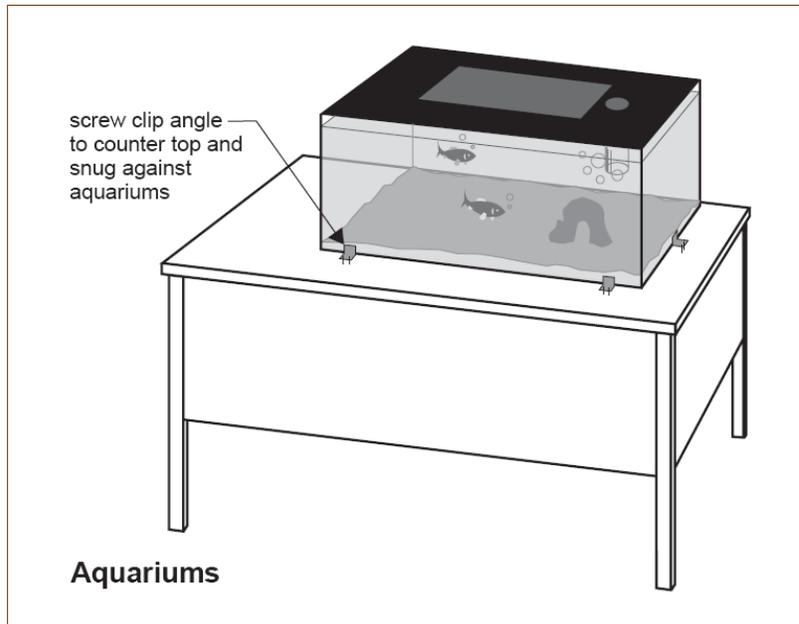
- Unsecured display and potted plant may fall, striking nearby occupants or blocking doors and exit ways for evacuation during an emergency.

Recommendations

- Secure display case to floor.
- Use angle bracket if needed.
- Secure contents to shelves using hook-and-loop or similar devices.
- Avoid placing unsecure items on top of case.
- Secure art objects or potted plants with ropes, chains or cables attached to eyebolts installed into wall studs or blocking.

Notes

- Display case must have safety glass.
- Shelves in display case must be secured.



Hazards

Unsecured aquariums may fall:

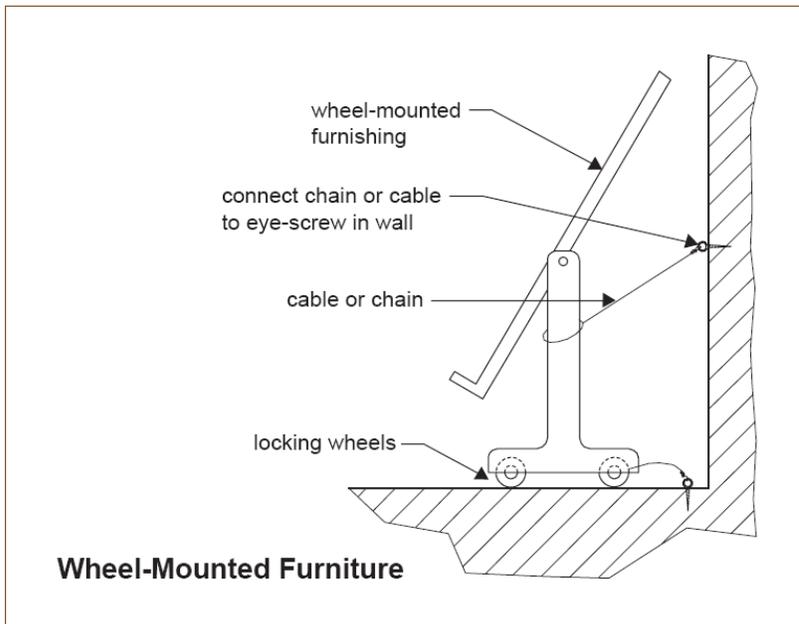
- Striking nearby occupants,
- Blocking exit ways during an emergency,
- Flooding adjacent spaces.

Recommendations

- Fasten clip angle to tabletop against each side of the aquarium.

Notes

- As shown in the illustration, the tabletop has a larger perimeter than the aquarium floor. If the aquarium is on a stand that has the same size perimeter as the aquarium floor, the stand should be anchored to the wall or floor in addition to the aquarium being fastened to the stand.
- Locate aquarium away from doors and exit ways.



Hazards

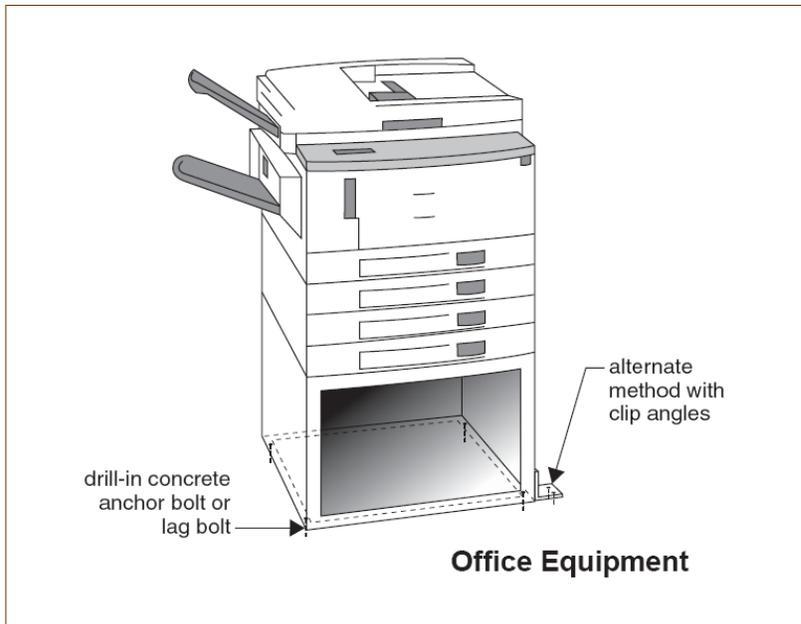
- Unsecured wheel-mounted furniture may roll or fall, striking nearby occupants or blocking doors and exit ways for evacuation during an emergency.

Recommendations

- Install eye screws to wall and secure furniture to eye screws with cable, chain, or rope.
- Replace free rolling wheels with lockable wheels.
- If wheels are not lockable, install eye screws to floor and secure furniture to eye screws with cable, chain, or rope.

Notes

- Eye screws must be installed into wall studs or blocking.



Hazards

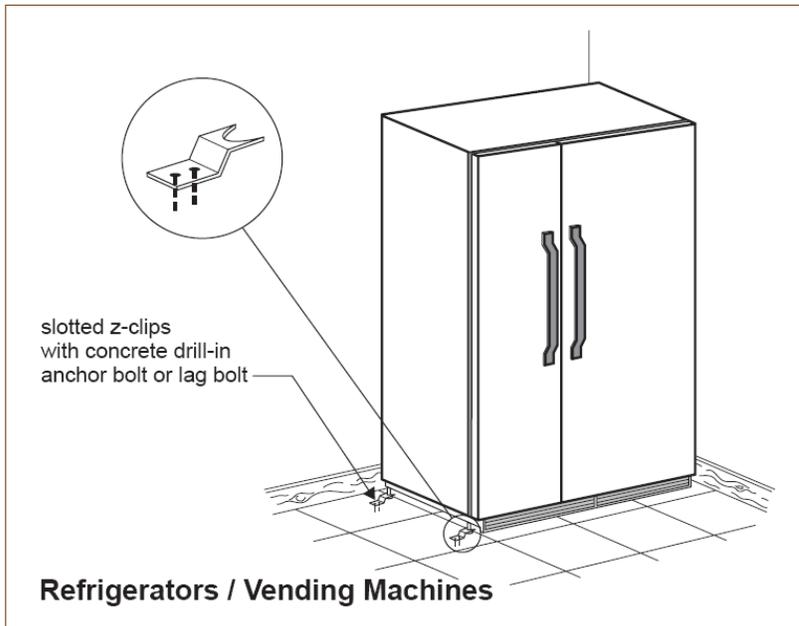
- Unsecured office equipment may fall, injuring nearby occupants.
- Fallen office equipment may damage electrical wiring, exposing occupants to electrical shock, or starting a fire.
- Unsecured office equipment may break as it falls, posing a threat to operational recovery.

Recommendations

- Secure office equipment to floor.

Notes

- Use concrete drill-in anchor bolts for concrete floor.
- Use lag bolts for wood floor. Lag bolts must be installed into floor beams or blocking.
- Bolts must be installed through metal framing of office equipment. Do not install through thin gauge housing panels.
- If clip angles are used, attach clip angles to metal framing of the equipment. Do not attach to thin gauge housing panels.



Hazards

Unsecured refrigerator or vending machines may slide or tip:

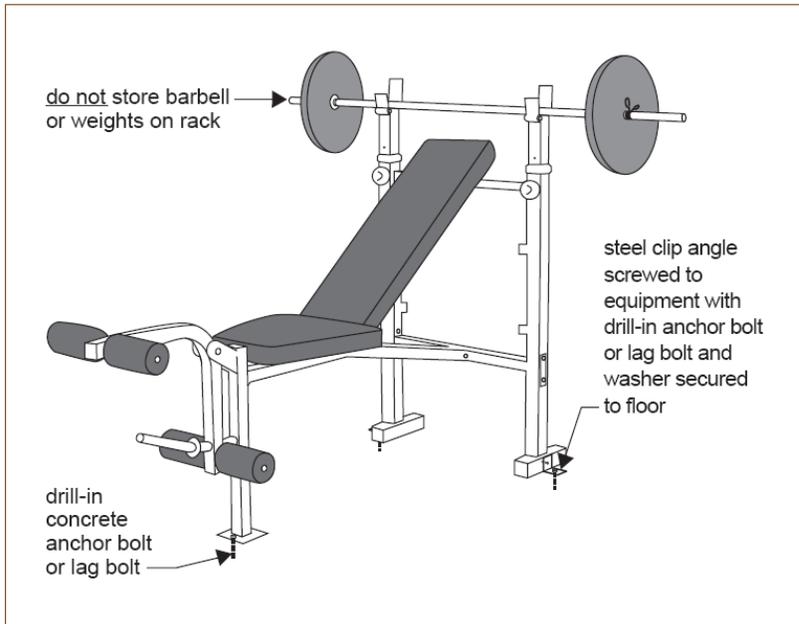
- Striking nearby occupants,
- Blocking doors and exit ways,
- Interrupting utility services,
- Causing gas leak, fire, etc.

Recommendations

- Secure refrigerators or vending machines to floor with slotted z-clips or clip angle.

Notes

- Slotted z-clip must have minimum of two bolts to the floor.
- Relocate refrigerator or vending machines away from doors and exit ways.



Hazards

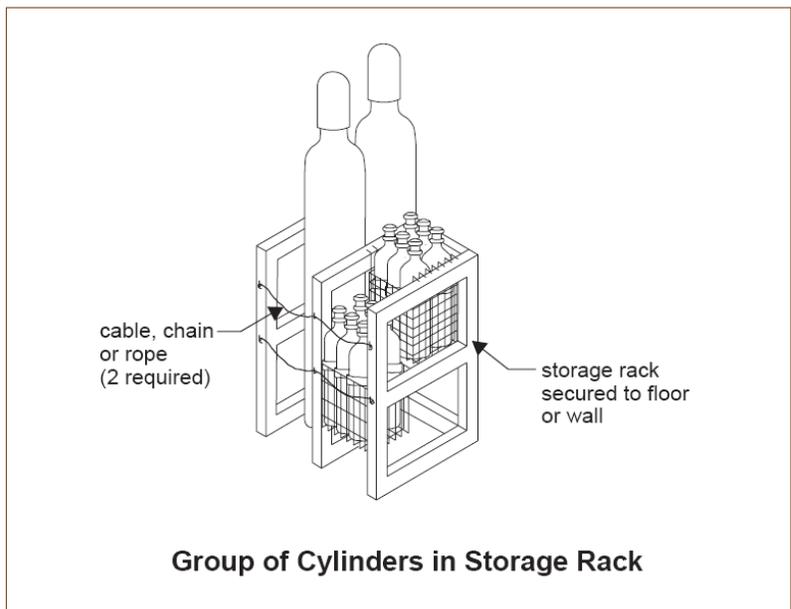
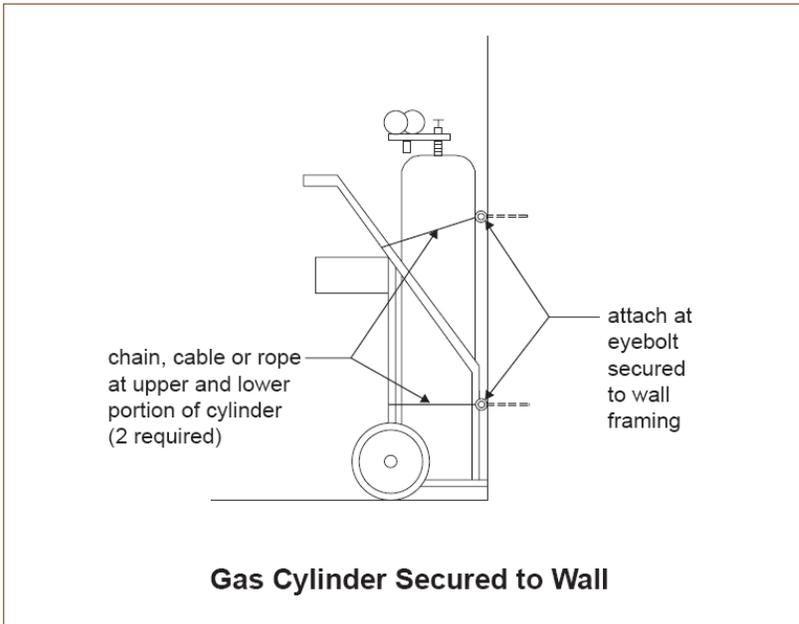
- Unsecured shop/gym equipment may fall, injuring nearby occupants or blocking doors or exit ways for evacuation during an emergency.

Recommendations

- Secure equipment to concrete floor with concrete drill-in anchor bolt at each leg.
- Secure equipment to wood floor with lag bolt at each leg. Lag bolt must be installed into floor joists or blocking.
- When clip angle is required, screw clip angle to equipment and fasten to floor with either concrete drill-in anchor or lag bolts.

Notes

- Do not store weights or bar bells on press bench. Store weights in weight rack/shaft that is secured to the floor.



Hazards

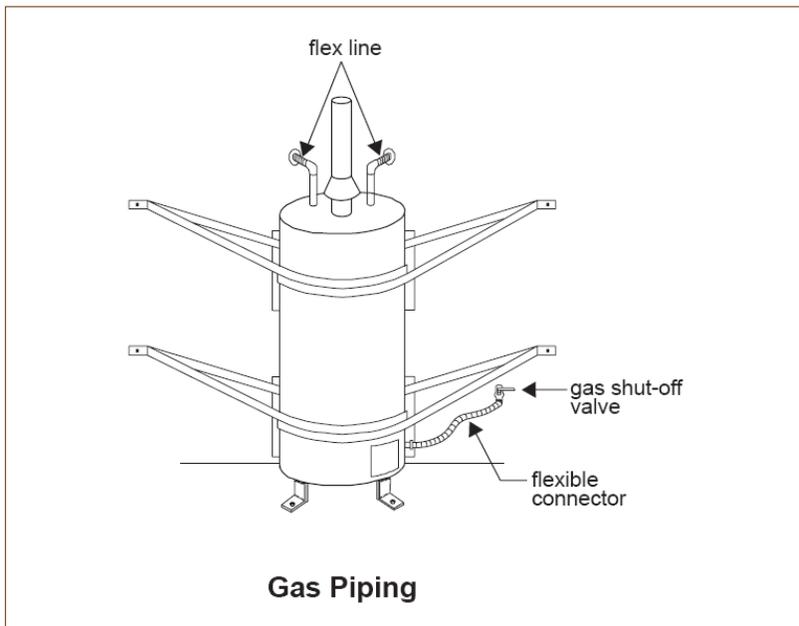
- Unsecured cylinders or tanks, including oxygen and compressed air tanks, may fall over and damage the shut-off valve, releasing hazardous or flammable contents.
- A tank with a damaged shut-off valve may result in the tank or valve becoming a projectile.
- Unsecured cylinders may fall over, striking or rolling and striking nearby occupants.

Recommendations

- Secure each cylinder or tank to a wall with two restraints (one restraint at the upper and the other at the lower portion of the cylinder).
- Alternatively to providing wall restraints, cylinders or tanks may be kept within a storage rack or compartment that is secured to a wall or floor.
- Store gas cylinders or tanks in non-occupied areas, and away from exit routes or exit doors.

Notes

- Chain, cable or rope restraints must be attached to eyebolts or other closed hook structural fasteners.
- Eyebolts or other fasteners must be attached to wall framing (studs or blocking).



Hazards

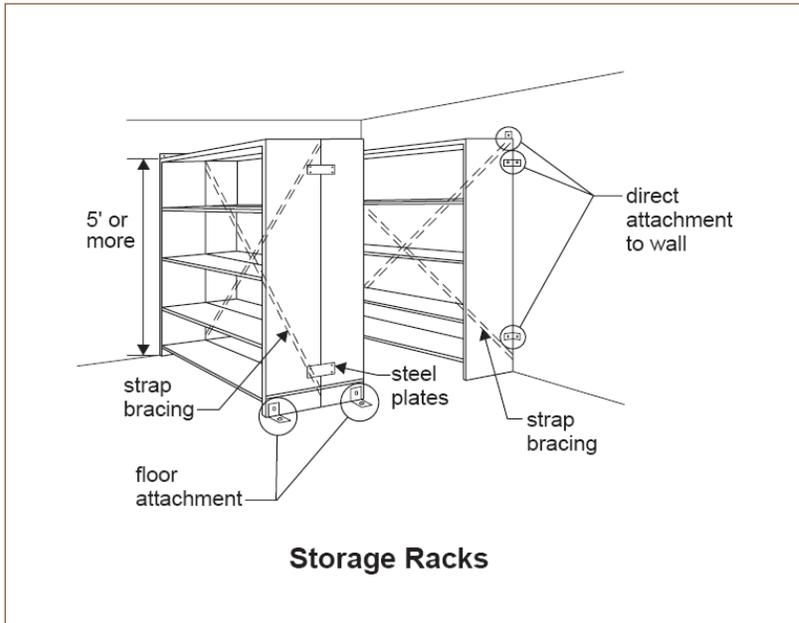
- Gas piping may break, causing gas leaks that can harm nearby occupants, or starting a fire.

Recommendations

- Install flexible piping when connecting to mechanical equipment such as water heater.
- Install seismic-actuated gas shutoff valve or excess flow gas shutoff valve.

Notes

- Mechanical equipment must also be anchored.
- See “Resources” for links to DGS information regarding gas shut-off valves and devices.



Hazards

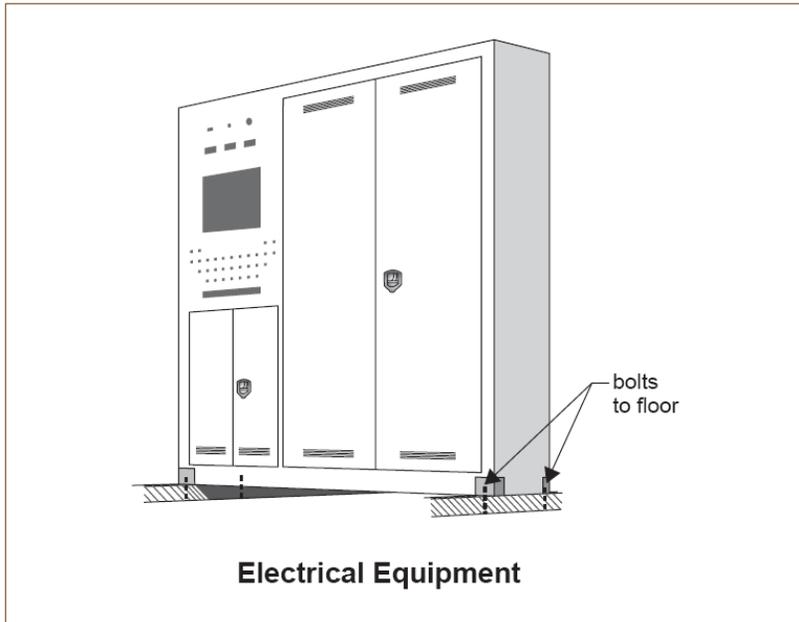
- Unsecured storage racks may fall, striking nearby occupants or blocking doors and exit ways for evacuation during an emergency.

Recommendations

- Secure with clip angles, bolts, or screws to floor.
- Strengthen with x-straps on backside.

Notes

- Fasteners should be installed into framing of storage racks.
- Locate heavy items to low level shelves.
- Consult a qualified architect or structural engineer for seismic bracing requirements.



Hazards

Unsecured electrical equipment may slide or fall:

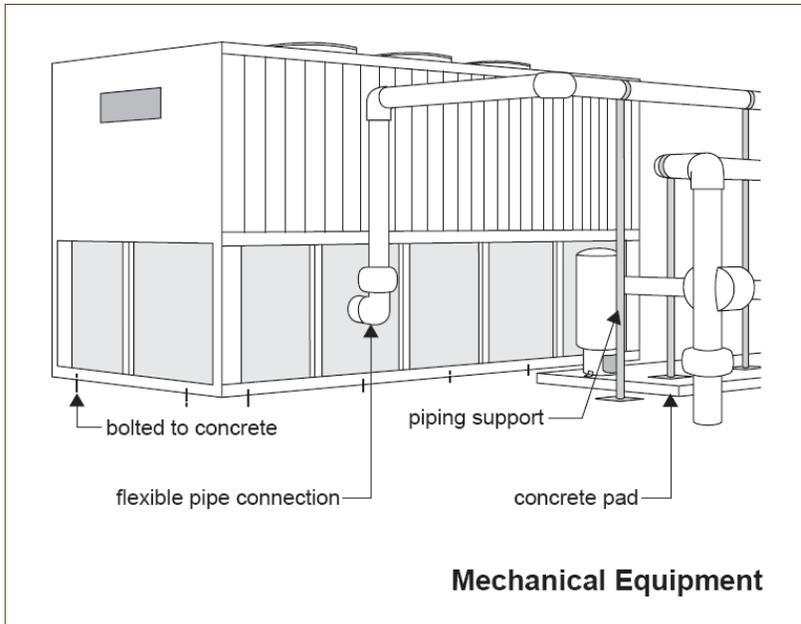
- Interrupting vital utility services in an emergency,
- Injuring nearby occupants,
- Damaging electrical wiring that would cause electrical shocks or fires.

Recommendations

- Secure electrical equipment to floor.
- Provide flexible cable connection to equipment.

Notes

- Consult a qualified architect or professional engineer for seismic anchorage requirements.
- Use concrete drill-in anchor bolts for concrete floor.
- Use lag bolts for wood floor. Lag bolts must be installed into floor beams or blocking.
- Bolts must be installed through metal framing of electrical equipment. Do not install through thin gauge housing panels.



Hazards

Unsecured mechanical equipment may slide or fall:

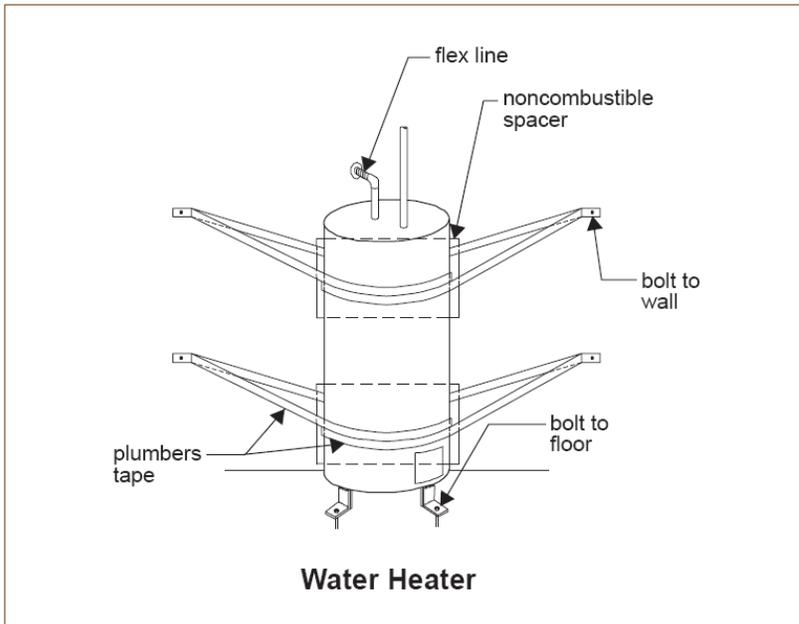
- Striking occupants nearby,
- Damaging electrical wiring water lines, or gas lines,
- Causing interruption to vital utility services,
- Exposing nearby occupants to electrical shocks,
- Starting a fire.

Recommendations

- Secure mechanical equipment to roof. Clip angles may be used.

Notes

- Mechanical equipment must have flexible conduits or pipes.
- Consult a qualified architect or professional engineer for seismic anchorage requirements.
- When vibration isolation is required, consider using vibration isolators that are pre-approved by the Office of Statewide Health Planning and Development (OSHPD).



Hazards

Unsecured plumbing equipment such as a water heater may slide or fall:

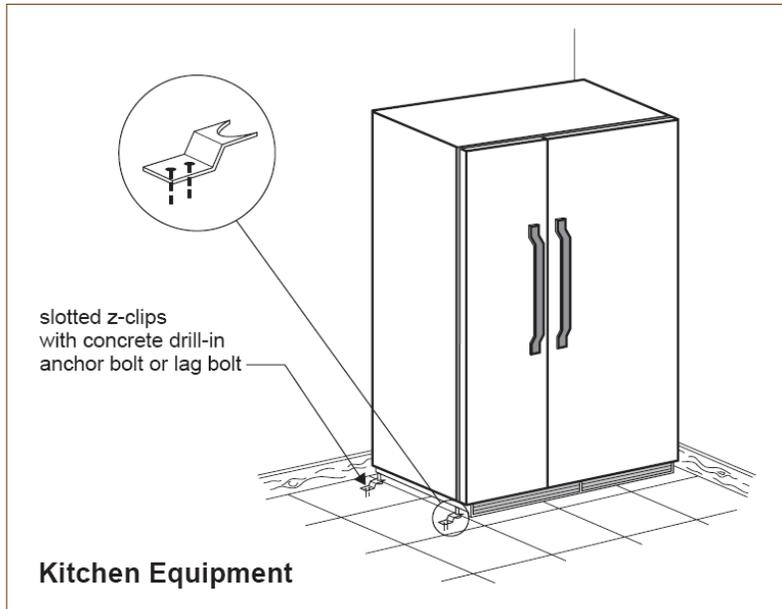
- Striking nearby occupants,
- Spilling hot water on floor or nearby occupants, or
- Rupturing gas lines.

Recommendations

- Secure base of water heater by bolting to floor and,
- Secure water heater to wall with plumber's tapes, or other methods recommended by the DGS – Division of the State Architect (DSA).
- See "Resources" for more information.

Notes

- Use concrete drill-in anchor bolts for concrete floor, and wall.
- Use lag bolts for wood floor and wall. Lag bolts must be installed into floor beams, wall studs, or blocking.
- Space between wall and water heater must be shimmed tight with non-combustible at the locations of the plumber's tape.
- See "Resources" for links to DGS guidelines for Earthquake Bracing of Residential Water Heaters.



Hazards

Unsecured kitchen equipments may fall:

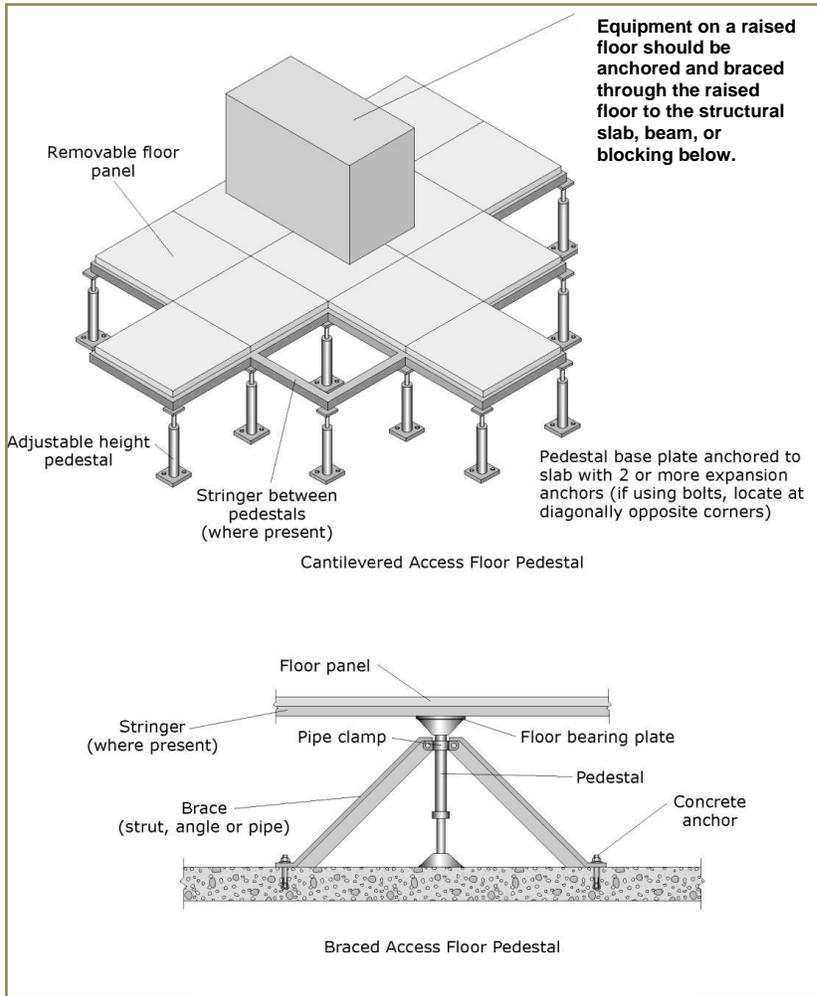
- Striking nearby occupants,
- Blocking doors and exit ways for evacuation during an emergency,
- Interrupting utility services, or causing gas leak, fire, etc.

Recommendations

- Secure kitchen equipment to floor with slotted z-clips or clip angle.
- Store and secure equipment and bins on rollers

Notes

- Slotted z-clip must have minimum of two bolts to the floor.
- Relocate kitchen equipment away from doors and exit ways.
- Consult a qualified architect or professional engineer for seismic anchor requirements.
- See “Resources” for more information from the Sheet Metal and Air Conditioning Contractor National Association (SMACNA) regarding kitchen ventilation systems.



Equipment mounted on access floor (modified from: FEMA E-74).

Hazards

- Unsecured computer access floors may collapse.
- Unsecured equipment located on access floors may slide, causing damage to itself, other equipment and walls.
- Fallen floor and equipment may injure occupants and block exit ways.

Recommendations

- Access floor base pedestals should be anchored to the floor slab. Taller pedestals may also need diagonal bracing.
- Light weight equipment placed on access floors should be tethered/restrained.
- Heavy equipment should be anchored to the structural slab below the access floor by installing an independent frame or supplemental bracing components under the access floor.

Notes

- If unrestrained equipment on castors is present, provide lips on cable openings through access floor to prevent wheels from getting stuck.
- Consult a qualified architect or professional engineer for seismic anchor requirements for raised floors and equipment supported by raised floors.

Resources / References

Where URLs are listed in this section, they are “live” as of February 2011. Note that over time, links may go stale; also documents and regulations may be updated over time. An alternative to ensure current versions are accessed is to link to the reference via a search engine.

California Emergency Management Agency (Cal EMA)

- *Preparedness Webpage*: <http://www.calema.ca.gov/LandingPages/Pages/Plan-and-Prepare.aspx>
- *Hazard Mitigation Web Portal*: <http://hazardmitigation.calema.ca.gov/>
- *My Hazards*, Cal EMA’s multi-hazard preparedness tool: <http://myhazards.calema.ca.gov/>
- *The Great California ShakeOut*, Cal EMA’s and its partners’ statewide earthquake readiness campaign: <http://www.shakeout.org/>
- *Earthquake Country Alliance*, California’s statewide earthquake education and outreach stakeholder coalition: <http://www.earthquakecountry.org/>

Division of the State Architect (DSA)

- *California Building Standards Code, California Code of Regulations, Title 24*. 2010: http://www.bsc.ca.gov/title_24/t24_2010ried.htm
- *Interpretation of Regulations*, Division of the State Architect, 1 January 2011: <http://www.dgs.ca.gov/dsa/Resources/IRManual.aspx#IRManual>
- *Metal Suspension Systems for Lay-In Panel Ceilings (IR 25)*: http://www.documents.dgs.ca.gov/dsa/pubs/IR_25-5_06-22-09.pdf
- *Guidelines for Earthquake Bracing of Residential Water Heaters*, Division of the State Architect: http://www.documents.dgs.ca.gov/dsa/pubs/waterheaterbracing_11_30_05.pdf
- *DSA Gas Shut-off Valves Certification Program*: http://www.dgs.ca.gov/dsa/resources/pubs.aspx#gas_shutoff
- *Gas Shutoff Devices Comparison Table*: http://www.dsa.dgs.ca.gov/dsa/documents/gas_shutoff/gas_shutoff.pdf

Federal Emergency Management Agency (FEMA)

- *Resources for Parents and Teachers*, FEMA’s preparedness site for schools: <http://www.fema.gov/kids/teacher.htm>
- *FEMA E-74 Reducing the Risks of Nonstructural Earthquake Damage-A Practical Guide*, 4th Edition Federal Emergency Management Agency, January 2011: <http://www.fema.gov/library/viewRecord.do?id=4626>
- *Design guide for Improving School Safety in Earthquakes, Floods, and High Winds (FEMA 454)*, Federal Emergency Management Agency, January 2004: <http://www.fema.gov/library/viewRecord.do?fromSearch=fromsearch&id=2418>
- *Installing Seismic Restraints for Mechanical Equipment (FEMA 412)*, Federal Emergency Management Agency, December 2002: <http://www.fema.gov/library/viewRecord.do?id=1557>

- *Installing Seismic Restraints for Electrical Equipment (FEMA 413)*, Federal Emergency Management Agency, January 2004: <http://www.fema.gov/library/viewRecord.do?id=1436>
- *Installing Seismic Restraints for Duct and Pipe (FEMA 414)*, Federal Emergency Management Agency, January 2004: <http://www.fema.gov/library/viewRecord.do?id=1437>
- *Design Guide for Improving School Safety in Earthquakes, Floods and High Winds (FEMA 424)*, Federal Emergency Management Agency, January 2004: <http://www.fema.gov/library/viewRecord.do?id=1986>
- *Seismic Considerations for Steel Storage Racks Located in Areas Accessible to the Public (FEMA 460)*, Federal Emergency Management Agency, September 2005: <http://www.fema.gov/library/viewRecord.do?id=1439>

Technical Codes, Standards, and Manuals

- *Minimum Design Loads for Buildings and Other Structures (ASCE/SEI 7-05)*. American Society of Civil Engineers, 2005.
- *Earthquake-Actuated Automatic Gas Shutoff Devices (ANSI/ASCE/SEI 25-06)*. American Society of Civil Engineers, 2006.
- *Seismic Rehabilitation of Existing Buildings (ASCE/SEI 41-06)*. American Society of Civil Engineers, 2006.
- *2006 International Building Code (IBC 2006)*. International Code Council, 2009.
- *Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd ed.* Sheet Metal and Air Conditioning Contractors' National Association, 2008.
- *Kitchen Ventilation Systems & Food Service Equipment Guidelines*. Sheet Metal and Air Conditioning Contractors' National Association, 2001.

Other Documents

- *Seismic Design Criteria of Nonstructural Systems for New School Facilities and Existing School Facilities*. Salt Lake City School District, 30 April 2001.
- *Nonstructural Earthquake Manual for K-12 Schools in Washington*. Washington office of the Superintendent of Public Instruction. <http://www.k12.wa.us/SchFacilities/Publications/NSEQguide.aspx>
- *Alteration and Repair of Unreinforced Masonry Chimneys*. City of Seattle, 14 October 2004. <http://www.seattle.gov/dclu/codes/dr/DR2004-5.pdf>
- *Advances in the Protection of Museum Collections from Earthquake Damage*. The Paul J. Getty Museum and Getty Conservation Institute, 2006.
- *Building an Emergency Plan, a Guide for Museums and other Cultural Institutions*. The Paul J. Getty Museum and Getty Conservation Institute, 1999.
- *Kitchen Ventilation Systems and Food Service Equipment Guidelines*, Sheet Metal and Air Conditioning Contractors' Association (SMACNA): <http://www.smacna.org/bookstore/>
- *Seismic Restraint Manual Guidelines for Mechanical Systems*, Sheet Metal and Air Conditioning Contractor National Association (SMACNA): <http://www.smacna.org/bookstore/>

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Earthquake Hazards Checklist

SCHOOL NAME:	INVENTORY DATE:
BUILDING NAME/ID:	INVENTORY BY:
ROOM NAME/ID:	

1	CEILING AND OVERHEAD	PAGE	ITEM PRESENT?		ITEM COMPLIES?		NOTES
			YES	NO	YES	NO	
	• light fixtures – hanging/pendant	7	<input type="checkbox"/>	<input type="checkbox"/>			
	• recessed light fixtures at suspended ceiling	8	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• recessed HVAC registers at suspended ceiling	8	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• suspended ceiling (metal grid lay-in acoustical panel)	9	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• hanging displays and plants	10	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• suspended space heaters/AC units	11	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• decorative ceiling/lattice work	12	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• conduit/piping	13	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• ductwork	14	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• lath/plaster soffits (exterior)	15	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• tile roofing (exterior)	16	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• unreinforced masonry chimney (exterior)	17	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2	WALL-MOUNTED ITEMS	PAGE					
	• shelving	21	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• wall-mounted cabinets/lockers/coat closets	22	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• wall-mounted TVs, video monitors, and speakers	23	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• pictures/wall decorations/signs	24	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• fire extinguisher	25	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• interior walls	26	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• free-standing and cubicle partitions	27	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• windows/entry glass	28	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3	FURNITURE & EQUIPMENT	PAGE					
	• file cabinets	31	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• bookcases	32/33	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• desktop and countertop equipment	34	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• equipment on cart (video, projectors)	35	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• display cases/art objects/potted plants	36	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• aquariums	37	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• equipment on wheels/rollers (e.g. piano, chalkboard)	38	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• copy machines/printers	39	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• refrigerators/vending machines	40	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• shop and gym equipment	41	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• gas cylinders	42	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• gas piping (shutoff valve/flex connector)	43	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• storage racks	44	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• electrical equipment (cabinets, switch gear, transformers)	45	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• mechanical equipment (chillers, fans)	46	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• plumbing equipment (water heater, tanks, pumps)	47	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• kitchen equipment (oven, range, hood, refrigerator/freezer, dishwasher)	48	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
	• raised access floors with computer or electronic equipment	49	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	