

*An Online PDH Course
brought to you by
CEDengineering.com*

Coastal Construction: Installing Mechanical Equipment and Utilities

Course No: S01-006
Credit: 1 PDH

Gilbert Gedeon, P.E.



Continuing Education and Development, Inc.

P: (877) 322-5800
info@cedengineering.com

www.cedengineering.com



12 Installing Mechanical Equipment and Utilities

This chapter provides guidance on design considerations for elevators, exterior-mounted and interior mechanical equipment, and utilities (electric, telephone, and cable TV systems and water and wastewater systems). Protecting mechanical equipment and utilities is a key component of successful building performance during and after a disaster event.



CROSS REFERENCE

For resources that augment the guidance and other information in this Manual, see the Residential Coastal Construction Web site (<http://www.fema.gov/rebuild/mat/fema55.shtm>).

12.1 Elevators

Elevators are being installed with increasing frequency in elevated, single-family homes in coastal areas. The elevators are generally smaller than elevators in non-residential buildings but are large enough to provide handicap accessibility and accommodate small household furniture and equipment.

Small (low-rise) residential elevators that are added as part of a post-construction retrofit are usually installed in a shaft independent of an outside wall. Residential elevators designed as part of new construction can be installed in a shaft in the interior of the structure. In either case, the elevator shaft must have a landing, which is usually at the ground level, and a cab platform near the top. The bottom or pit of an elevator with a landing at the lower level is almost always below the BFE.

Appendix H in NFIP Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program* (FEMA 2010a), discusses the installation of elevator systems and equipment in the floodplain. As explained in the bulletin, elevator shafts and enclosures that extend below the BFE in coastal areas must be designed to resist hydrostatic, hydrodynamic, and wave forces as well as erosion and scour, but are not required to include hydrostatic openings or breakaway walls. In addition, elevator accessory equipment should be installed above the BFE, replaced with flood damage-resistant elements, or treated with flood damage-resistant paint or coatings to minimize flood damage.

For safety reasons, commercial and large (high-rise) elevators are designed with “fire recall” circuitry that sends the elevator to a designated floor during a fire so emergency services personnel can use the elevators. However, during flooding, this feature may expose the cab directly to floodwaters. Therefore, for elevators in coastal buildings, the elevator must be equipped with a float switch that sends the elevator cab to a level above the BFE. In addition, the design professional must ensure that the elevator stops at a level above the BFE when the power is lost. This can be accomplished by installing an emergency generator or a battery descent feature that is integrated into the float switch, as described in NFIP Technical Bulletin 4.

Finally, although elevators and elevator equipment are permitted for building access and may be covered by flood insurance, their presence, location, and size can affect flood insurance premiums. For buildings in Zone V, the NFIP considers an elevator enclosure a building enclosure or an obstruction, which may be subject to an insurance rate loading depending on:

- Square footage of the enclosure
- Value of the elevator equipment
- Location of the elevator equipment in relation to the BFE

12.2 Exterior-Mounted Mechanical Equipment

Exterior-mounted mechanical equipment can include exhaust fans, vent hoods, air conditioning units, duct work, pool motors, and well pumps. High winds, flooding, and seismic events are the natural hazards that can cause the greatest damage to exterior-mounted mechanical equipment.

12.2.1 High Winds

Equipment is typically damaged because it is not anchored or the anchorage is inadequate. Damage may also be caused by inadequate equipment strength or corrosion. Relatively light exhaust fans and vent hoods are commonly blown away during high winds. Air conditioning condensers, which are heavier than fans and vent hoods, can also be blown off of buildings.

Considering the small size of most exhaust fans, vent hoods, and air-conditioning units used on residential buildings, the following prescriptive attachment recommendations should be sufficient for most residences:

- For curb-mounted units, #14 screws with gasketed washers
- For curbs with sides smaller than 12 inches, one screw at each side of the curb

- For curbs between 12 and 24 inches, two screws per side
- For curbs between 24 and 36 inches, three screws per side
- For buildings within 3,000 feet of the ocean, stainless steel screws
- For units that have flanges attached directly to the roof, #14 pan-head screws, a minimum of two screws per side, and a maximum spacing of 12 inches o.c.
- Air conditioning condenser units, 1/2-inch bolts at the four corners of base of each unit

If the equipment is more than 30 inches above the curb, the attachment design should be based on calculated wind loads. ASCE 7-10 contains provisions for determining the horizontal and lateral force and the vertical uplift force on rooftop equipment for buildings with a mean roof height less than or equal to 60 feet. The lateral force is based on the vertical area of the equipment as projected on a vertical plane normal to the direction of the wind. The uplift force is based on the horizontal area of the equipment as projected on a horizontal plane above the equipment and parallel to the direction of the wind.

Until equipment manufacturers produce more wind-resistant equipment, job-site strengthening of vent hoods is recommended. One approach is to use 1/8-inch-diameter stainless steel cables. Two or four cables are recommended, depending on design wind conditions. Alternatively, additional heavy straps can be screwed to the hood and curb.

To avoid corrosion problems in equipment within 3,000 feet of the ocean shoreline (including sounds and backbays), nonferrous metal, such as aluminum, stainless steel, or steel with minimum G-90 hot-dip galvanized coating, is recommended for the equipment, equipment stands, and equipment anchors. Stainless steel fasteners are also recommended. See Section 11.6 for guidance regarding attic vents.

12.2.2 Flooding

Flood damage to mechanical equipment is typically caused by the failure to elevate equipment sufficiently, as shown in Figure 12-1. Figure 12-2 shows proper elevation of an air-conditioning condenser in a flood-prone area.

Exterior-mounted mechanical equipment in one- to four-family buildings is normally limited to the following:

- Air-conditioning condensers
- Ductwork (air supply and return)
- Exhaust fans
- Pool filter motors
- Submersible well pumps

Floodwaters can separate mechanical equipment from the supports and sever the connection to mechanical or electric



CROSS REFERENCE

For additional information, see FEMA 348, *Protecting Building Utilities From Flood Damage – Principles and Practices for the Design and Construction of Flood-Resistant Building Utility Systems* (FEMA 1999), and Fact Sheet 8.3, *Homebuilder's Guide to Coastal Construction*, in FEMA P-499 (FEMA 2010b).

Figure 12-1.
Condenser damaged as
a result of insufficient
elevation, Hurricane
Georges (U.S. Gulf Coast,
1998)



Figure 12-2.
Proper elevation of
an air-conditioning
condenser in a
floodprone area;
additional anchorage is
recommended



systems. Mechanical equipment can also be damaged or destroyed when inundated by floodwaters, especially saltwater. Although a short period of inundation may not destroy some types of mechanical equipment, any inundation of electric equipment causes, at a minimum, significant damage to wiring and other elements.

Minimizing flood damage to mechanical equipment requires elevating it above the DFE. Because of the uncertainty of wave heights and the probability of wave run-up, the designer should consider additional elevation above the DFE for this equipment.

In Zone V, mechanical equipment must be installed either on a cantilevered platform supported by the first floor framing system or on an open foundation. A cantilevered platform is recommended. However, if the platform is not cantilevered, it is strongly recommended that the size of the elements, depth, and structural integrity of the open foundation that is used to support mechanical equipment be the same as the primary building foundation. Although smaller diameter piles could be used because the platform load is minimal, the smaller piles are more susceptible to being broken by floodborne debris, as shown in Figure 12-3.

In Zone A, mechanical equipment must be elevated to the DFE on open or closed foundations or otherwise protected from floodwaters entering or accumulating in the equipment elements. For buildings constructed over crawlspaces, the ductwork of some heating, ventilation, and air-conditioning systems are routed through the crawlspace. The ductwork must be installed above the DFE or be made watertight in order to minimize flood damage. Many ductwork systems today are constructed with insulated board, which is destroyed by flood inundation.

**NOTE**

Although the 2012 IBC and 2012 IRC specify that flood damage-resistant materials be used below the BFE, in this Manual, flood damage-resistant materials are recommended below the DFE.



Figure 12-3.
Small piles supporting a platform broken by floodborne debris

12.2.3 Seismic Events

Residential mechanical equipment is normally fairly light. Therefore, with some care in the design of the attachment of the equipment for resistance to shear and overturning forces, these units should perform well during seismic events. Because air-conditioning units that are mounted on elevated platforms experience higher accelerations than ground-mounted units, extra attention should be given to attaching these units in areas that are prone to large ground accelerations.

12.3 Interior Mechanical Equipment

Interior mechanical equipment includes but is not limited to furnaces, boilers, water heaters, and distribution ductwork. High winds normally do not affect interior mechanical equipment. Floodwaters, however, can cause significant damage to furnaces, boilers, water heaters, and distribution ductwork. Floodwaters can extinguish gas-powered flames, short circuit the equipment's electric system, and inundate equipment and ductwork with sediment.

The following methods of reducing flood damage to interior equipment are recommended:

- Elevate the equipment and the ductwork above the DFE by hanging the equipment from the existing first floor or placing it in the attic or another location above the DFE.
- In areas other than Zone V (where enclosure of utilities below the BFE is not recommended), build a waterproof enclosure around the equipment, allowing access for maintenance and replacement of equipment parts.

12.4 Electric Utility, Telephone, and Cable TV Systems

Electric utilities serving residential buildings in coastal areas are frequently placed in harsh and corrosive environments. Such environments increase maintenance and shorten the lifespan of the equipment. Common electric elements of utilities in residential buildings that might be exposed to severe wind or flood events, which increase maintenance and shorten the lifespan further, are electric meters, electric service laterals and service drops from the utility company, electric panelboards, electric feeders, branch circuit wiring, receptacles, lights, security system wiring and equipment, and telephone and cable television wiring and equipment.

The primary method of protecting elements from flooding is to elevate them above the DFE, but elevation is not always possible. Floodplain management requirements and other code requirements sometimes conflict. One conflict that is difficult to fully resolve is the location of the electric meter. Figure 12-4 shows a bank of meters and electric feeds that failed during Hurricane Opal.

Utility companies typically require electric meters to be mounted where they can be easily read for billing purposes; meters are usually centered approximately 5 feet above grade. They are normally required by utility regulations to be no higher than eye level. However, this height is often below the DFE for coastal homes, and the placement therefore conflicts with floodplain management requirements that meters be installed above the DFE. Since meter sockets typically extend 12 inches below the center of the meter, design floods



Figure 12-4.
Electric service meters
and feeders that were
destroyed by floodwaters
during Hurricane Opal
(1995)

that produce 4 feet of flooding can cause water to enter the meter socket and disrupt the electric service. When a meter is below the flood level, electric service can be exposed to floodborne debris, wave action, and flood forces. Figure 12-5 shows an electric meter that is easily accessible by the utility company but is above the DFE.

Since many utility companies no longer manually read meters, there may be flexibility in meter socket mounting, preferably above the design flood. The use of automatic meter reading (“smart meters”) by electric utility companies is increasing. The designer should consult the utility to determine whether smart meters can be placed higher than meters that must be read manually.

Similar situations often exist with other electrical devices. For example, switches for controlling access and egress lighting and security sensors occasionally need to be placed below the DFE. The following methods are recommended when necessary to reduce the potential for damage to electric wiring and equipment and to facilitate recovery from a flood event:

- **Wiring methods.** Use conduit instead of cable. Placing insulated conductors in conduits allows flood-damaged wiring to be removed and replaced. The conduit, after being cleaned and dried, can typically be reused. In saltwater environments, non-metallic conduits should be used.
- **Routing and installation.** Install main electric feeders on piles or other vertical structural elements to help protect them from floating debris forces. Since flood damage is often more extensive on the seaward side of a building, routing feeders on the landward side of the structural elements of the building can further reduce the potential for damage. Do not install wiring or devices on breakaway walls. Figure 12-5 is an illustration of recommended installation techniques for electric lines, plumbing, and other utility elements.
- **Design approach.** Install the minimum number of electric devices below the DFE that will provide compliance with the electric code. Feed the branch circuit devices from wiring above the DFE to minimize the risk of flood inundation.

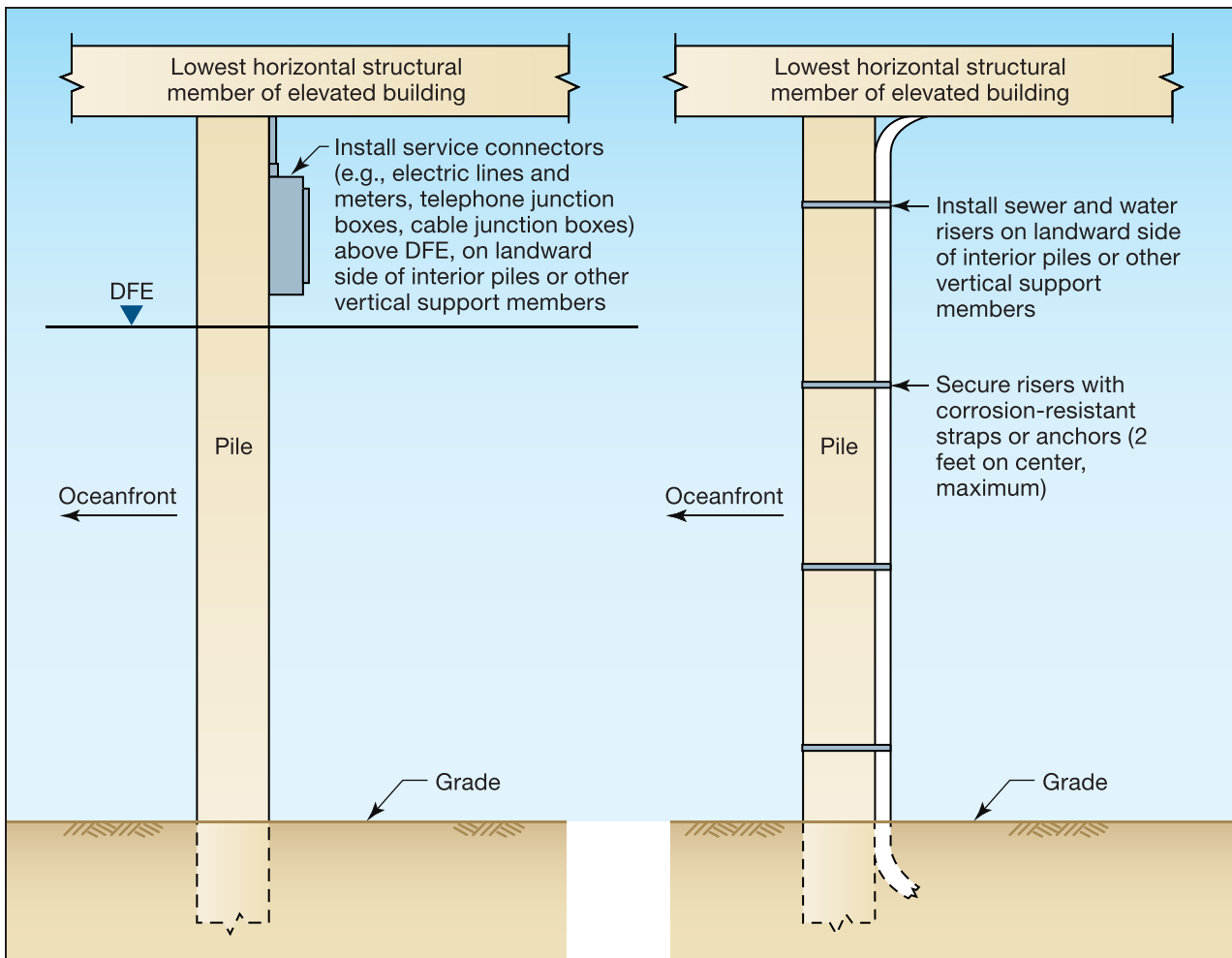


Figure 12-5.
Recommended installation techniques for electric and plumbing lines and utility elements

- Service style.** Feed the building from underground service laterals instead of overhead electric service drops. When overhead services are needed, avoid penetrating the roof with the service mast to reduce the potential for roof damage and resulting water infiltration. Figure 12-6 illustrates the vulnerability of roof damage and resulting water infiltration when an electric service mast penetrates a roof.
- Panel location.** Install branch circuit and service panelboards above the DFE. If required to meet utility National Electrical Code requirements, provide a separate service disconnect remote to the panel.

Fact Sheet 8.3, *Protecting Utilities*, in FEMA P-499 contains other recommendations for reducing the vulnerability of utilities that supply buildings.

Direct wind damage to exterior-mounted electric utility equipment (see Figure 12-6) is infrequent in part because of the small size of most equipment (e.g., disconnect switches, conduit). Exceptions are satellite dishes, photovoltaic panels, and electric service penetrations through the roof. Satellite dish and photovoltaic panel failures are typically caused by the design professional's failure to perform wind load calculations and provide for adequate anchorage.



Figure 12-6.
Damage caused by
dropped overhead
service, Hurricane
Marilyn (U.S. Virgin
Islands, 1995)

12.4.1 Emergency Power

Because a severe wind event often interrupts electric service, designers and homeowners need to make a decision about the need for backup power.

Emergency power can be provided by permanently installed onsite generators or by temporary generators brought to the site after the event. For permanently installed units, the following is recommended:

- Locate the generator above the DFE.
- If located on the exterior of the building, place the unit to prevent engine exhaust fumes from being drawn into doors, windows, or any air intake louvers into the building. If located on the inside of the building, provide ventilation for combustion air and cooling air and provision for adequately discharging exhaust fumes.
- Locate the fuel source above the DFE and store an amount of fuel adequate for the length of time the generator is expected to operate.
- Install the generator where its noise and vibration will cause the least disruption.
- Determine the expected load (e.g., heat, refrigeration, lights, sump pumps, sewer ejector pumps). Non-fuel-fired heating systems and most cooling systems require large generators. Capacity considerations may limit the generator to providing only freeze protection and localized cooling.
- Install manual or automatic transfer switches that prevent backfeeding power from the generator into the utility's distribution system. Backfeeding power from generators into the utility's distribution system



CROSS REFERENCE

For guidance on determining the proper size of an emergency generator, see Section VI-D of FEMA 259, *Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings* (FEMA 2001).

can kill or injure workers attempting to repair damaged electrical lines.

- Provide an “emergency load” subpanel to supply critical circuits. Do not rely on extension cords. Supply the emergency panel from the load side of a manual or automatic transfer switch.
- Determine whether operation of the generator will be manual or automatic. Manual operation is simpler and less expensive. However, a manual transfer switch requires human intervention. Owners should not avoid or delay evacuation to tend to an emergency power source.
- Size the generator, transfer switches, and interconnecting wiring for the expected load. The generator should be large enough to operate all continuous loads and have ample reserve capacity to start the largest motor load while maintaining adequate frequency and voltage control and maintaining power quality.

**WARNING**

Do not “backfeed” emergency power through the service panel. Utility workers can be killed!

12.5 Water and Wastewater Systems

Water and wastewater systems include wells, septic systems, sanitary systems, municipal water connections, and fire sprinkler systems.

12.5.1 Wells

For protection of well systems from a severe event (primarily a flood), the design must include a consideration of the following, at a minimum:

- Floodwaters that enter aquifers or saturate the soil can contaminate the water supply. FEMA P-348, *Principles and Practices for Flood-Resistant Building Utilities* (FEMA 1999), recommends installing a watertight encasement that extends from at least 25 feet below grade to at least 1 foot above grade.
- Non-submersible well pumps must be above the DFE.
- If water is to be available following a disaster, an alternative power source must be provided.
- The water supply line riser must be protected from hydrodynamic and floodborne debris impact damage; the supply line must be on the landward side of a pile or other vertical structural member or inside an enclosure designed to withstand the forces from the event (see Figure 12-5).
- Backflow valves must be installed to prevent floodwaters from flowing into the water supply when water pressure in the supply system is lost.

12.5.2 Septic Systems

Leach fields and septic tanks, and the pipes that connect them, are highly susceptible to erosion and scour, particularly in Coastal A Zone and Zone V with velocity flow risks. The best way to protect leach fields and other onsite sewage management elements is to locate them outside the floodplain.

If septic systems cannot be located outside the floodplain, the design of septic systems for protection from severe events must include a consideration of the following, at a minimum:

- If the septic tank is dislodged from its position in the ground, the piping will be disconnected, releasing sewage into floodwaters. Also, the tank could damage the nearest structure. Therefore, bury the system below the expected depth of erosion and scour, if possible, and ensure the tank is anchored to prevent a buoyancy failure.
- The sewage riser lines and septic tank risers must be protected from water and debris flow damage; risers should be on the landward side of a pile or other vertical structural member or inside an enclosure designed to withstand the forces from the event (see Figure 12-5).

If leach fields, pipes, and tanks cannot be located outside the floodplain, one possible way to protect them is to bury them below the expected scour depth. However, many local health codes or ordinances restrict or even prohibit the placement of septic elements in the floodplain. In these cases, alternate sewage management systems must be used.

Because leach fields rely on soil to absorb moisture, saturated soil conditions can render leach fields inoperable. This problem and its potential mitigating measures depend on complex geotechnical considerations. Therefore, a geotechnical engineer and/or a qualified sewer designer should be consulted for the design and installation of leach fields.

12.5.3 Sanitary Systems

To protect sanitary systems from a severe event, the design must include a consideration of the following, at a minimum:

- Sanitary riser lines must be protected from water and debris flow damage; risers should be on the landward side of a pile or other vertical structural member or inside an enclosure designed to withstand the forces from the event (see Figure 12-5).
- When the line breaks at the connection of the building line and main sewer line, raw sewage can flow back out of the line, contaminating the soil near the building. A check valve in the line may help prevent this problem.



WARNING

In some areas, high groundwater levels may preclude the installation of septic tanks below the level of expected erosion and scour.

12.5.4 Municipal Water Connections

If water risers are severed during a coastal event, damage to the water supply system can include waste from flooded sewer or septic systems intruding into the water system, sediment filling some portion of the pipes, and breaks in the pipes at multiple locations. Protecting municipal water connections is accomplished primarily by protecting the water riser that enters the building from damage by debris. See Section 12.5.1 for more information.

12.5.5 Fire Sprinkler Systems

Protecting the fire sprinkler system is similar to protecting the other systems discussed in Section 12.5. The primary issue is to locate the sprinkler riser such that the location provides shielding from damage. In addition, there must be consideration to the location of shutoff valves and other elements so that if an unprotected portion of the fire water supply line is damaged, the damage is not unnecessarily added to the damage caused by the natural hazard event.

12.6 References

- ASCE (American Society of Civil Engineers). 2010. *Minimum Design Loads for Buildings and Other Structures*. ASCE Standard ASCE 7-10.
- FEMA (Federal Emergency Management Agency). 1999. *Principles and Practices for Flood-Resistant Building Utilities*. FEMA P-348.
- FEMA. 2001. *Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings*. FEMA 259.
- FEMA. 2010a. *Elevator Installation for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program*. FEMA NFIP Technical Bulletin 4.
- FEMA. 2010b. *Homebuilder's Guide to Coastal Construction*. FEMA P-499.
- FEMA. 2010c. *National Flood Insurance Program Flood Insurance Manual*.
- ICC (International Code Council). 2011a. *International Building Code*. 2012 IBC. Country Club Hills, IL: ICC.
- ICC. 2011b. *International Residential Code for One-and Two-Family Dwellings*. 2012 IRC. Country Club Hills, IL: ICC.