Fact Sheet 3.4.1: Building Utility Systems—Heating, Ventilation and Air Conditioning

The mitigation objective of this Fact Sheet is to improve the resilience of the components of heating, ventilation and air conditioning (HVAC) systems to allow a building to retain partial functionality or to be quickly repaired following a flood, with an end goal of rapidly returning the building to full use.

HVAC systems are used to heat and cool indoor spaces. In public buildings, HVAC systems may include chilled water and hot water systems and active ventilation systems for controlling indoor temperatures, humidity levels and indoor air quality. HVAC components generally are not flood resistant, so they will be damaged or destroyed when exposed to flood water. Wind and wind-borne debris can damage or destroy rooftop-mounted equipment. Mitigation actions can be taken to reduce physical damage and functional loss of HVAC system components from floods and hurricanes so public facilities can provide essential community services during and after these disasters.

Wind and wind-related mitigation of HVAC system components and equipment located inside the building or inside rooftop enclosures can be accomplished by making sure the building envelope and enclosures are built to resist wind pressures, wind-borne debris and wind-driven rain. Wind and wind-related mitigation of non-enclosed rooftop HVAC system components and equipment can be accomplished by making sure the equipment is well anchored to resist the design wind forces for the geographic location.

Added protection can result from following best practices, which often go beyond minimum codes and standards. Additional information about measures that can be implemented to mitigate against wind are discussed in Fact Sheet 3.2, *Wall Systems and Openings;* Fact Sheet 3.3.1, *Sloped Roof Systems*; and Fact Sheet 3.3.2, *Low-Slope Roof Systems*. Mitigation of rooftop mechanical equipment to resist high winds and wind-driven rain also is covered in Fact Sheet 3.3.1, *Sloped Roof Systems*; and Fact Sheet 3.3.2, *Low-Slope Roof Systems*. Because other fact sheets cover wind-related hazard mitigation of rooftop-mounted HVAC system components, this fact sheet focuses primarily on flood mitigation.

Key Terms and Definitions

HVAC systems are mechanical systems generally associated with building heating, ventilation and air conditioning that use air, water or other fluids as a thermal transfer medium to heat and cool the structure. The basic components of fluid-based HVAC systems commonly used in large public buildings are shown in Figure 3.4.1.11. The basic components of forced-air HVAC systems common to small public buildings are shown in Figure 3.4.1.2.

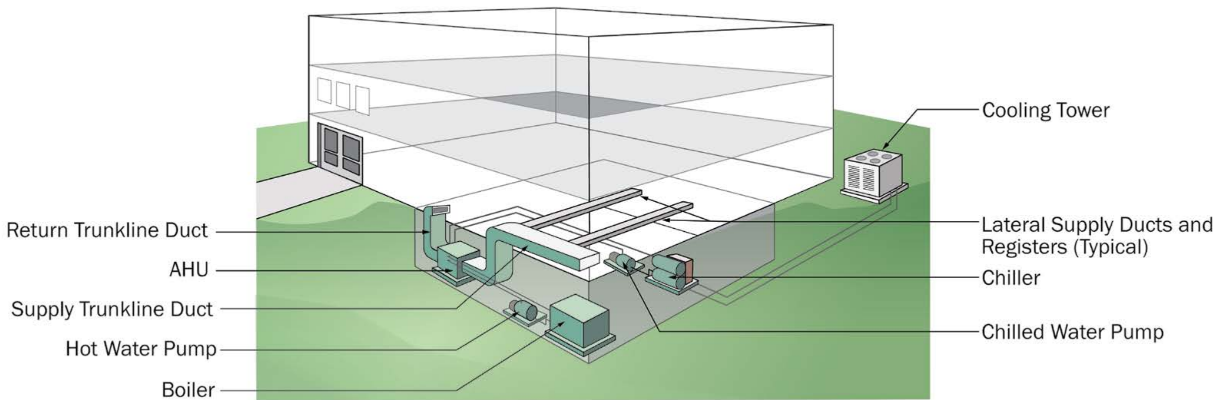


Figure 3.4.1.1. Basic components of a large public building fluid-based HVAC system. Note HVAC components on upper floors are not shown in this simplified graphic.

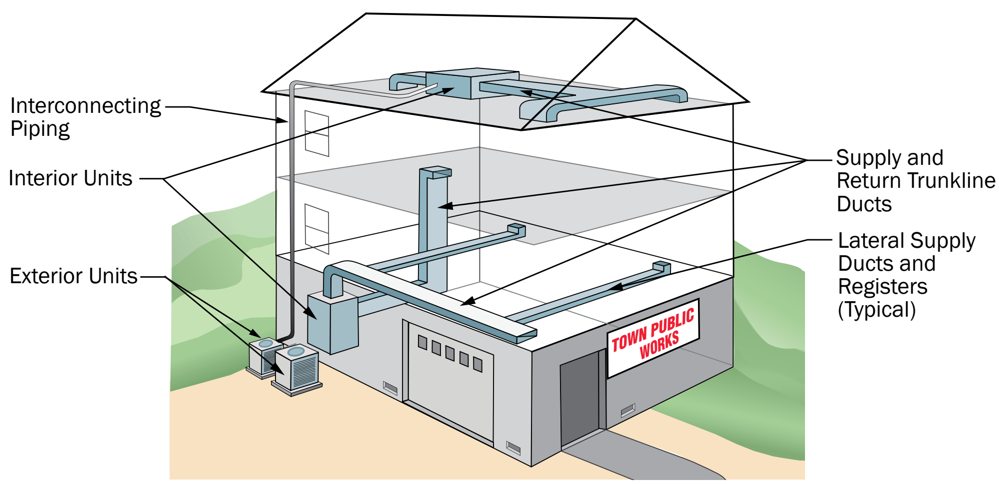


Figure 3.4.1.2. Basic components of a small public building supplied by two forced-air HVAC systems.

HVAC systems are comprised of two types of components:

- **Primary Components**—Components that must work for the system to work. When a primary component does not work, the entire system stops working. Examples of primary components of HVAC systems include air handling units, condenser units, and evaporative coils.
- **Secondary components**—Components that can lose function without causing complete loss of building system operation. When secondary components do not work, the system may not function at its highest level of service or it may cause service interruptions to a portion of the building. Examples of secondary components of HVAC systems include ducts, supply grills and return louvers.

Mitigating existing HVAC systems typically is done by elevating and partially protecting HVAC components, with some in-place component protection also recommended. Refer to FEMA P-348, *Protecting Building Utility Systems from Flood Damage*, for more details. In addition, new construction and substantial improvements for proposed building sites that are in flood-prone areas must comply with the National Flood Insurance Program (NFIP) requirements.

Table 3.4.1.1. summarizes some common mitigation solutions that can improve the performance of building HVAC system components. These strategies then are discussed in the sections that follow.

Table 3.4.1.1. Common HVAC System Mitigation Solutions

Solutions and Options	***Coastal Flood***	***Riverine Flood***
Mitigation Solution: Elevate or Relocate		
Option 1: Elevate or Relocate	✓	✓
Mitigation Solution: Dry Floodproof		
Option 1: Dry Floodproof	✓	✓
Mitigation Solution: Wet Floodproof		
Option 1: Wet Floodproof	✓	✓

Mitigation Solution: Elevate or Relocate

Since most HVAC components are not water resistant and can be damaged or destroyed when exposed to floodwater, elevation is the most effective overall solution for mitigating both primary and secondary components.

Option 1: Elevate or Relocate

Specific examples of HVAC mitigation measures that use this strategy include:

- Elevate or raise (in place) outdoor HVAC compressors and interior units onto platforms or pedestals above the flood protection level, as shown in Figure 3.4.1.3.

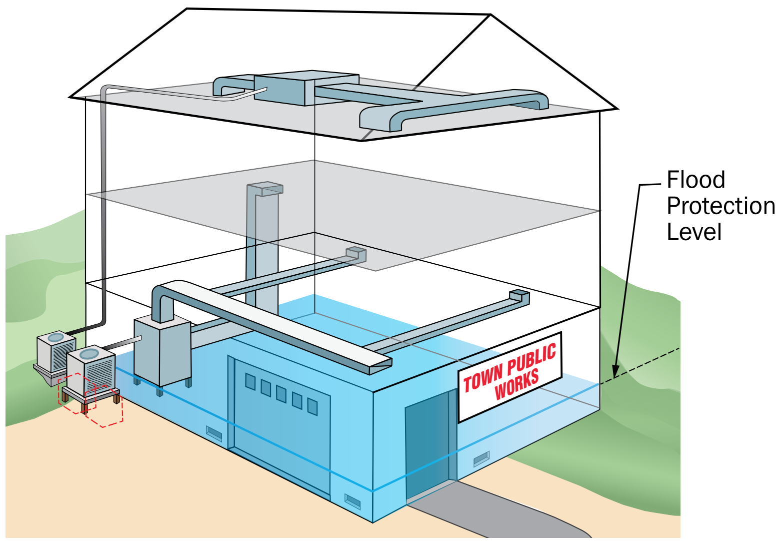


Figure 3.4.1.3. Elevation of indoor and outdoor HVAC components on platforms above flood protection level for small public building.

- In coastal flood zones (Zone V), anchor HVAC equipment to platforms attached to the main structure using corrosion-resistant connectors and fasteners to protect from storm surge and wave action. Platforms and pedestals should be well anchored to withstand being dislodged by flood forces.
  - HVAC equipment placed on these platforms also should be anchored to resist wind forces. The equipment's dimensions will determine its vulnerability to wind forces.
- If primary components shift due to flood and wind forces, their connections to fixed electrical, piping and duct components can be strained or disconnected. Where permissible, install flexible connections such as flexible conduit, cords and cables, piping and ducts with appropriate fittings. Availability of flexible for plumbing systems that operate at high pressures or convey reactive fluids may be limited.
- Elevate interior equipment in place by suspending ducts from the floor framing if that level is high enough to protect the components from flood or consider if the floor framing itself can be raised above the flood protection level.

If elevation in place is not possible, relocate all primary and secondary HVAC components to higher floors above the flood protection level, as shown in Figure 3.4.1.4.

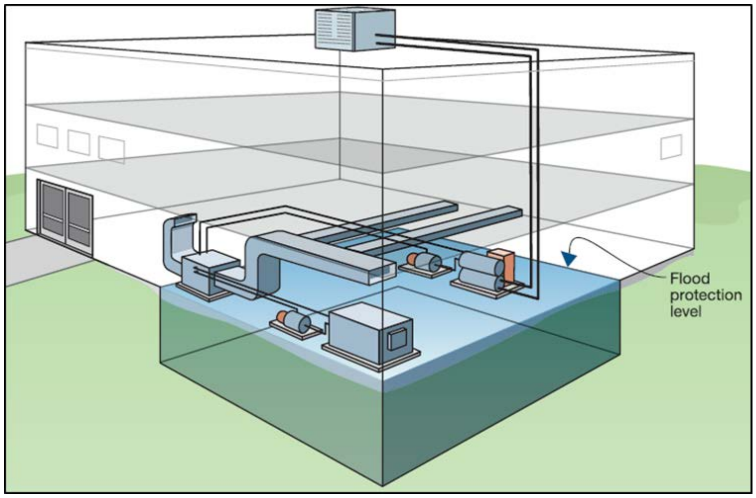
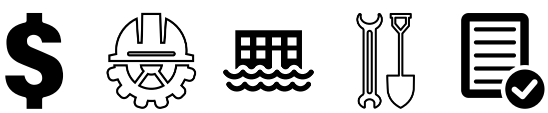


Figure 3.4.1.4. Elevation of indoor HVAC components from basement to first floor above flood protection level for large public building, with outdoor HVAC components relocated to the rooftop.

- Relocating HVAC system components to a higher floor will require having or creating enough space to put the equipment. Space may need to be traded by moving another less-critical function to a lower floor. Relocating system components is likely to require additional design by a licensed engineer.
- Elevating or relocating equipment may cost more than some other mitigation strategies, but these solutions are the most effective approach to mitigating HVAC system components against flood impacts.

CONSIDERATIONS:



Mitigation Solution: Dry Floodproof

When primary HVAC components cannot be elevated, dry floodproofing may be an effective solution to protect equipment in-place.

Option 1: Dry Floodproof

Although options are few given the limited flood resistance of HVAC components, some specific examples of HVAC mitigation measures that can apply this strategy include:

- Protect HVAC equipment in-place with a low wall or step-over curb if the flood protection level is 12 inches or less.
  - Higher protective walls should have a gasketed entrance panel door or other closure type, as shown in Figure 3.4.1.5.
  - A secondary drainage system using a sump pump with backup power is recommended.

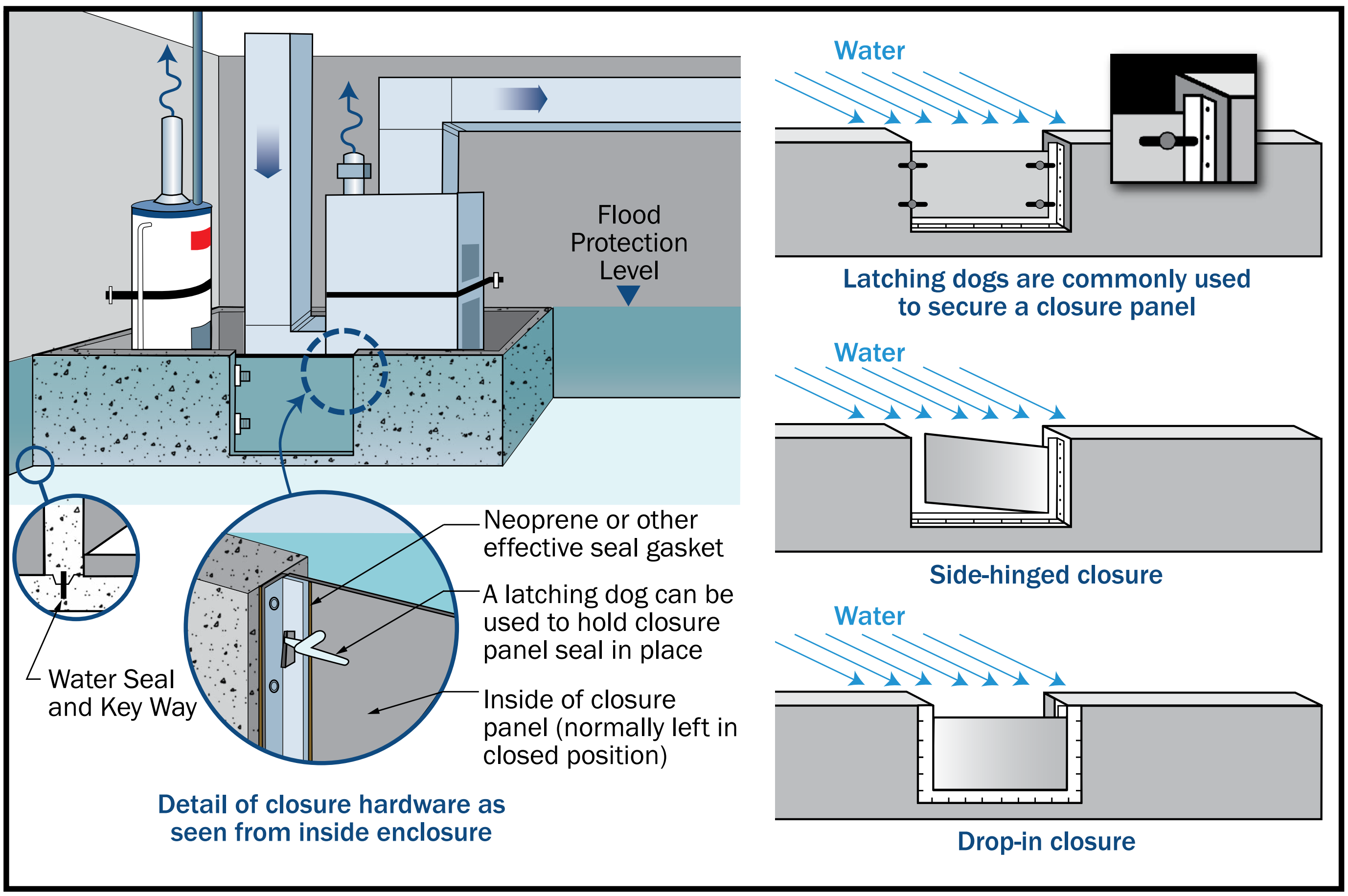


Figure 3.4.1.5. Dry floodproofing with a watertight wall and access gate can be used to protect HVAC and plumbing equipment (left); alternate dry floodproofing protective enclosures for protecting equipment (right).

- Place HVAC components within watertight vaults or protected areas built with reinforced walls and floors strong enough to withstand all flood forces. Make sure there is enough space to build the enclosures.

CONSIDERATIONS:

Mitigation Solution: Wet Floodproof

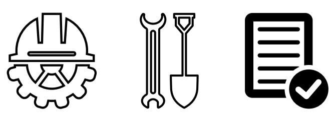
When piping for water-conveying portions of HVAC systems cannot be elevated above the flood protection level and dry floodproofing is not possible or practical, wet floodproofing can reduce system damage and repair time after a flood, helping to restore service more rapidly.

Option 1: Wet Floodproof

Some wet floodproofing mitigation options include:

- Create transition points between sections of the HVAC system that are above and below the flood protection level.
- Install piping unions above the required flood protection level for chilled- and hot-water systems to allow damaged components to be removed and replaced while minimizing disruption to the undamaged portions of the system.
- Install isolation devices above the required flood protection level, such as valves that control feed portions of piping exposed to floodwater, to make repair or replacement of damaged equipment faster and easier.
  - The valves allow damaged equipment to be isolated from undamaged sections and may allow the undamaged sections to function during repairs.
  - Similarly, dampers can be installed in lateral sections of exposed HVAC ducts that are fed from trunk-line ducts above the floodwater.

CONSIDERATIONS:



REFERENCES:

Detailed information on hurricane mitigation of building HVAC systems can be found in these publications. Much of the residential information applies to non-residential buildings as well.

American Society of Civil Engineers (ASCE). *Highlights of ASCE 24 Flood Resistant Design and Construction.* Available at: https://www.fema.gov/sites/default/files/2020-07/asce24-14_highlights_jan2015.pdf

Federal Emergency Management Agency (FEMA). 2007a. FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds.* Available at: https://www.fema.gov/sites/default/files/2020-08/fema543_design_guide_complete.pdf

FEMA. 2007b. FEMA 577, *Design Guide for Improving Hospital Safety in Earthquakes, Floods, and High Winds.* Available at: https://www.fema.gov/sites/default/files/2020-08/fema577_design_guide_improving_hospital_safety_2007.pdf

FEMA. 2010. FEMA P-424, *Risk Management Series: Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds.* Available at: https://www.fema.gov/sites/default/files/documents/fema_p-424-design-guide-improving-school-safety.pdf

FEMA. 2011. FEMA P-55, *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas.* Available at: https://www.fema.gov/emergency-managers/risk-management/building-science/publications?name=%22FEMA+P-55%2C+Coastal%22&field_keywords_target_id=All&field_document_type_target_id=All&field_audience_target_id=All

FEMA. 2013. FEMA P-936, *Floodproofing Non-Residential Buildings* Available at: https://www.fema.gov/emergency-managers/risk-management/building-science/publications?name=%22P-936%22&field_keywords_target_id=All&field_document_type_target_id=All&field_audience_target_id=All

FEMA. 2017. FEMA P-348, *Protecting Building Utility Systems from Flood Damage; Principles and Practices for Design and Construction of Flood Resistant Building Utility Systems.* Available at: https://www.fema.gov/sites/default/files/2020-07/fema_p-348_protecting_building_utility_systems_from_flood_damage_2017.pdf

FEMA. 2019. NFIP Technical Bulletin 8, *Corrosion Protection of Metal Connectors in Coastal Areas.* Available at: https://www.fema.gov/emergency-managers/risk-management/building-science/publications?name=%22Technical+Bulletin+8%22&field_keywords_target_id=All&field_document_type_target_id=All&field_audience_target_id=All