New and Substantially Improved Buildings

HVAC Systems

SECTION
3.1

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3.1 Heating, Ventilating, and Air Conditioning (HVAC) Systems

3.1.1 Introduction

NOTE:

This chapter applies to new and substantially improved structures that must be built in compliance with the minimum requirements of the NFIP. Many of the structures that were built prior to the adoption of floodplain management regulations by communities have building utilities systems that are not resistant to flood damages. For additional informatin on how to protect building utility sytems in these structures, see Chapter 4 on Existing Buildings.

In order to live and/or work in a fully enclosed structure, people must be provided comfortable living conditions. To achieve these conditions, the air within closed structures often is heated in the winter and cooled in the summer, and is continuously refreshed and circulated to maintain an adequate level of comfort. HVAC systems serve this function.

In general, HVAC system components can be divided into **Main Equipment** and the **Supporting Distribution System**. Some components of these systems are located indoors, while others are located outdoors. *Table 3.1.1* presents portions of the typical HVAC system and their typical locations. *Figure 3.1.1* shows a typical HVAC system installation in a flood-prone area.

	MAIN EQUIPMENT	SUPPORTING DISTRIBUTION SYSTEM
OUTDOOR	Compressor/Condenser/Heat pump/Evaporative cooler units	Gas/Oil storage tanks Gas/Oil fuel supply lines Electrical supply lines
INDOOR	Furnace with evaporator coil/ Air handler Boiler	Duct work (room air ducts–supply and return) Refrigerant lines Combustion air intake line Hydronic piping Pump Terminal units (radiators)

Table 3.1.1: HVAC system components

In general, the figures in this chapter attempt to illustrate some general practices that meet the requirements of the National Flood Insurance Program (NFIP). Local codes permit many variations that also meet NFIP regulations. Please refer to your local code officials for specific practices that may meet both NFIP regulations and local code.

3.1.2 NFIP Requirements

The NFIP requires that the HVAC system in a new or substantially improved structure located in a Special Flood Hazard Area (SFHA) be de-

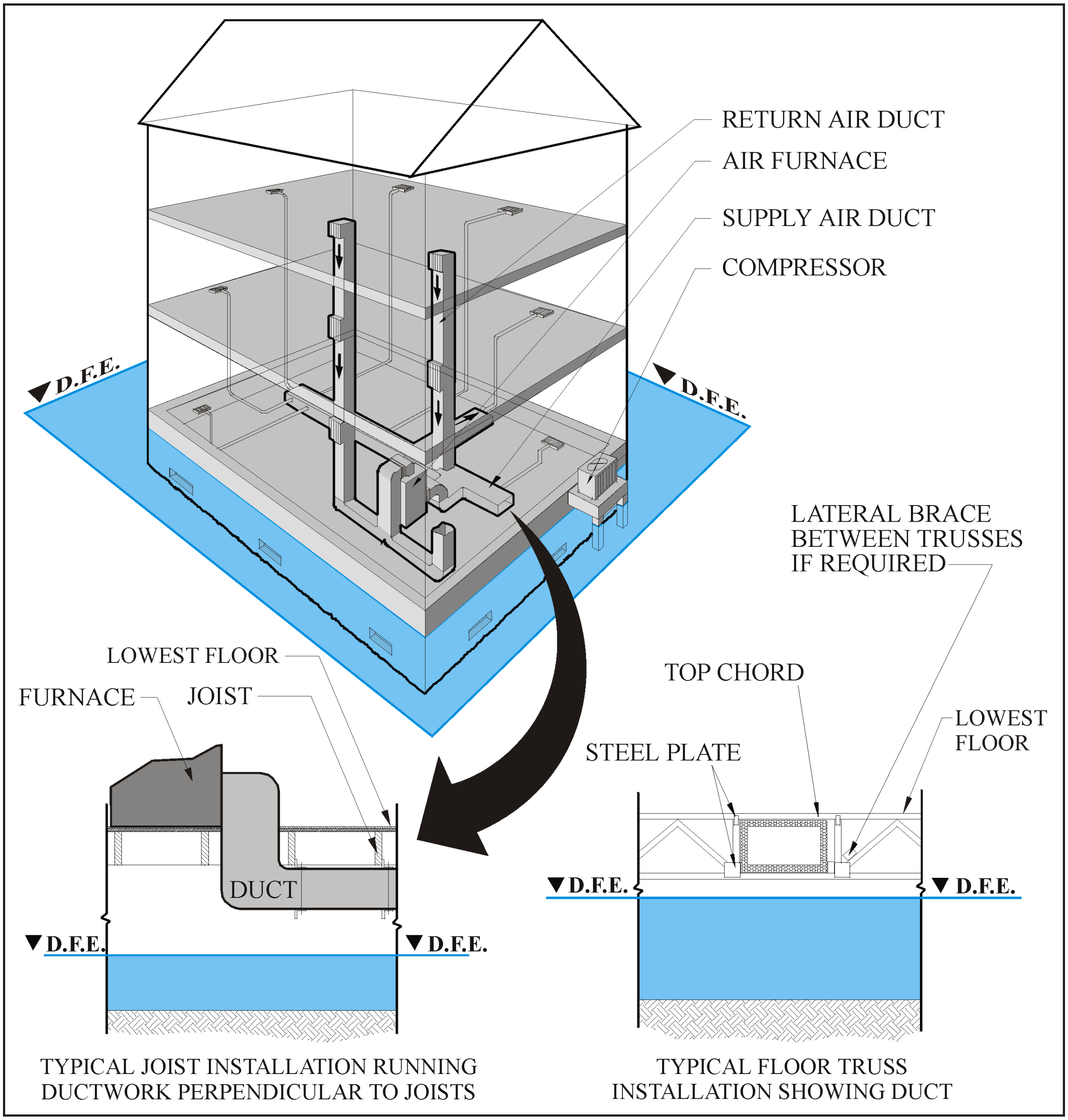


Figure 3.1.1: Main components of a typical HVAC system in a house in a flood-prone area

signed so that floodwaters cannot infiltrate or accumulate within any component of the system. *Table 3.1.2* summarizes NFIP compliant methods.

Methods of Mitigation	A Zones	V Zones
1. Elevation	Highly Recommended	Minimum Requirement
2. Component Protection	Minimum Requirement	Not Allowed*

Table 3.1.2: Summary of NFIP regulations
***Allowed only for those items required to descend below the DFE for service connections.**

NOTE:
The Design Flood Elevation (DFE) is a regulatory flood elevation adopted by a community that is the BFE, at a minimum, and may include freeboard, as adopted by the community.

1. **Elevation** refers to the location of a component above the Design Flood Elevation (DFE).

2. **Component Protection** refers to the implementation of design techniques that protect a component or group of components located below the DFE from flood damage by preventing floodwater from entering or accumulating within the sytem components.

3.1.3 Compressors, Heat Pumps, and Other Outdoor Equipment

CAUTION:
Always refer to local building codes, floodplain management regulations and other applicable requirements before installing HVAC equipment. Many states and communities have adopted more restrictive requirements than the NFIP minimums discussed in this manual.

With most outdoor HVAC equipment, the main issues presented by floodwaters are inundation, velocity flow, and debris impact. The control and power circuits and mechanical parts in HVAC equipment, even when they are designed for outdoor installation, are not designed to withstand inundation by floodwater. They are also not designed to withstand the dynamic forces of high velocity flow and debris impact. During inundation, the electric and electronic control and power units would likely short-circuit, and the mechanical equipment would fail to operate and may be torn away. Most of the metal components would eventually corrode and deteriorate, especially in areas inundated by floodwaters containing salt. High velocity flow in either riverine or coastal areas can dislodge equipment from their stands and separate connecting pipes, hoses, and power lines. These situations occurred in Topsail Beach, North Carolina during coastal flooding caused by Hurricane Fran in November of 1996. *Figure 3.1.3A* shows electric heat pumps that were dislodged due to the forces of velocity flow.

Figure 3.1.3A: Electric heat pumps dislodged from their stands by velocity flow during Hurricane Fran in Topsail Beach, North Carolina, in November 1996

Elevation

The most effective flood-resistant design for outdoor HVAC equipment is to strap or bolt the equipment onto a platform above the DFE. Some basic guidelines when elevating HVAC equipment are:

- The strapping or bolting mechanism must be designed to withstand wind, earthquake, and other required forces as specified in the local building codes and ordinances.
- In coastal areas, the platform can often be cantilevered out from the structure at an elevation above the DFE.
- If this is not possible, then the platform can often be supported on piles, posts, or columns that are embedded into the soil below the expected depth of erosion, scour, and frost.

CAUTION: Some codes specify access for maintenance and safety precautions for all building utility sytems, particularly in non-residential applications.

- If necessary, cross-bracing of piles and posts, together with concrete footings, should be used to increase the resistance of the platform to wind, velocity flow, and seismic forces (cross-bracing should only be installed parallel to the direction of flow to permit free passage of debris and floodwaters).
- In addition, the platform should be located on the landward side (in coastal areas) or the downstream side (in riverine areas) of the structure to protect againt velocity flows and debris impact.

NOTE: In a large residential or non-residential building it is common to locate the HVAC compressor on the roof of the building. The rooftop location for these units protects them from flood damage.

Figure 3.1.3B shows a typical cantilevered HVAC platform application.

The elevation of outdoor HVAC equipment on platforms is suitable for small residential and non-residential buildings.

No matter what structure the units are located on, HVAC units should be equipped with vibration dampening devices and the structures upon which

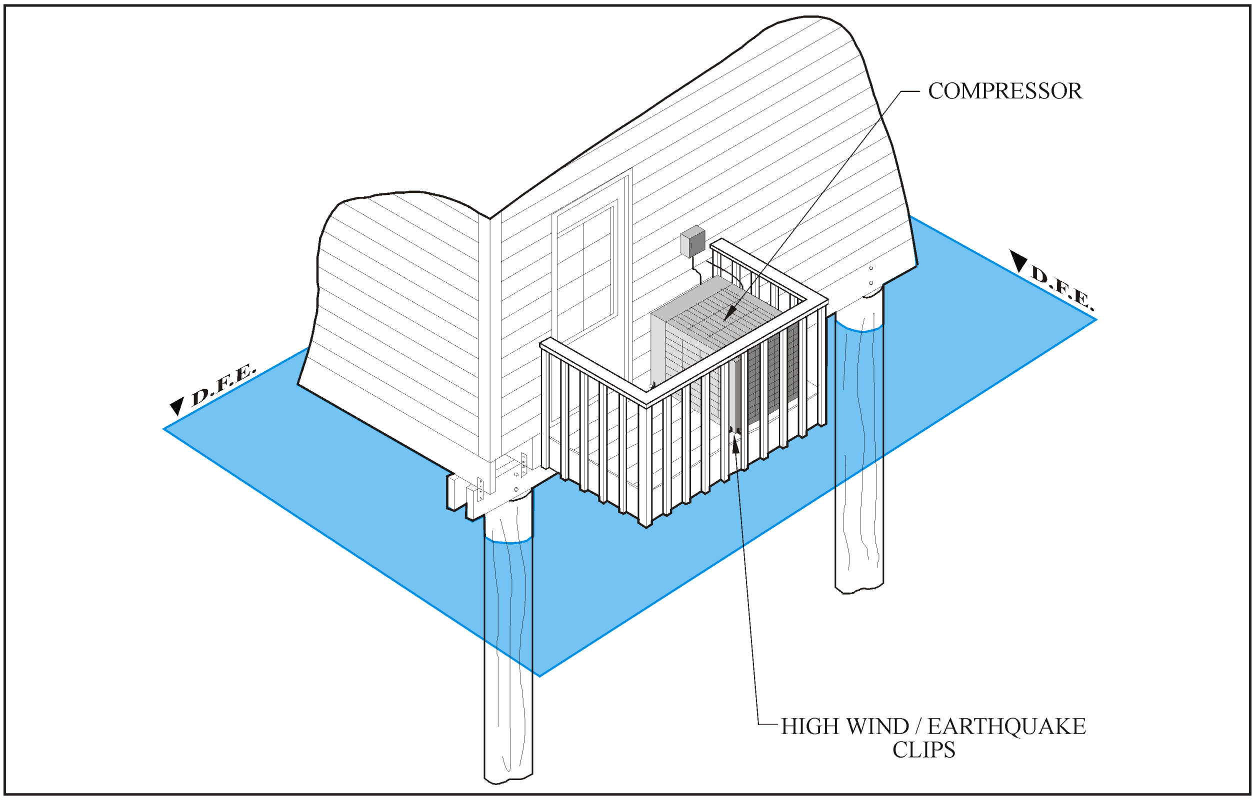


Figure 3.1.3B: A cantilevered compressor platform beside a house in a velocity flow area

they rest should be properly designed to withstand vibrations for extended periods of time. In addition, the units should be anchored in place so that the equipment is not permitted to move as a result of the vibrations.

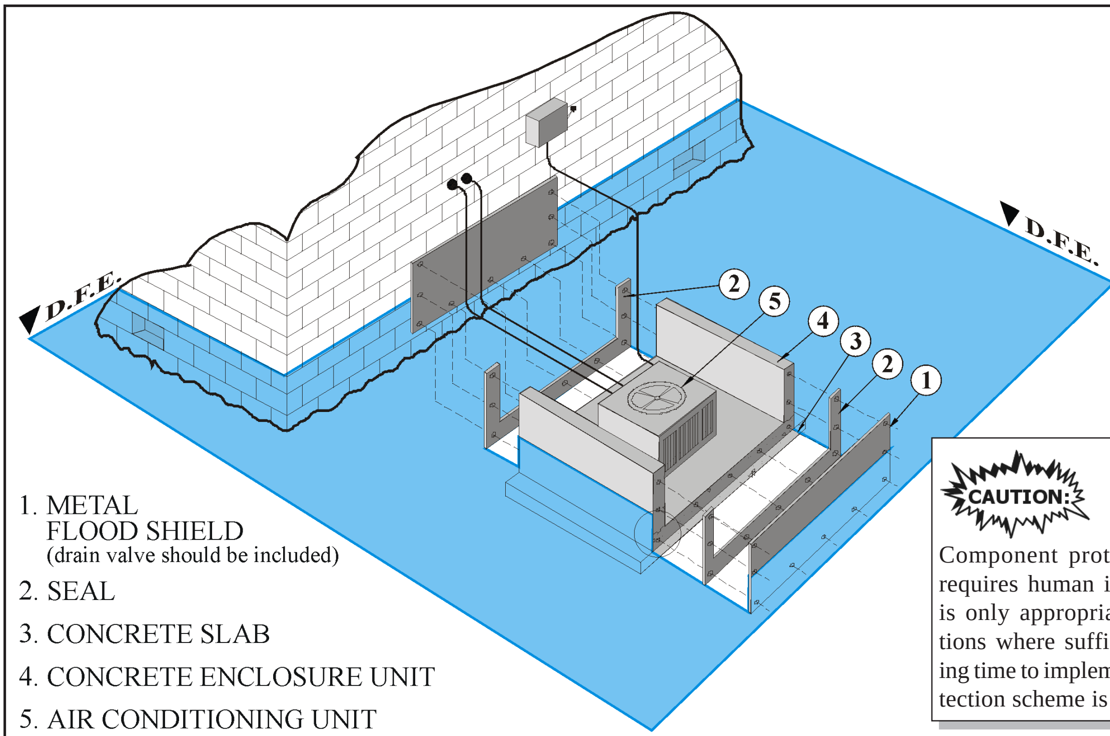
Air conditioning systems are equipped with condensate drain pans. These pans must be located to allow free draining above the DFE. If the drainpipe extends below the DFE, the system could back up and the drain could become a conduit for the introduction of floodwaters into the system. This would damage the unit, and could flood the area where the unit is housed.

Component Protection

Where outdoor HVAC main equipment located in an A Zone cannot be elevated above the DFE, it can still be protected from inundation by enclosing the unit within watertight walls. The top of the walls of the enclosure must be at or above the DFE, and there must be access for servicing. *Figure 3.1.3C* illustrates a typical concrete and steel flood shield arrangement. Enclosures can also be constructed of steel.

NOTE:

Component protection is only permitted in A zones.



CAUTION:

Component protection that requires human intervention is only appropriate in locations where sufficient warning time to implement the protection scheme is provided.

Figure 3.1.3C: Use of flood shields to enclose an outdoor compressor unit at grade

CAUTION:
Component protection that requires human intervention is only appropriate in locations where sufficient warning time is provided to implement the flood protection scheme.

If a watertight enclosure without a roof cover is used, allowances must be made for drainage of the structure to prevent rainwater from damaging the equipment located inside the enclosure. A typical enclosure might include a check valve that will permit water leaving the enclosure, but will prevent it from entering the enclosure.

Note that component protection using watertight walls is generally used when construction of pedestals is not feasible. For flood protection of HVAC system equipment in most new and substantially improved buildings, construction of pedestals provides a simpler and more cost-effective solution than watertight walls.

3.1.4 Furnaces, Boilers, Water Heaters, and Other Indoor Equipment

Floodwaters inundating a gas or oil furnace would extinguish the flame in the burner of the furnace and/or cause a short-circuit of the furnace's ignition control component and possible corrosion damage. In an electric furnace inundated by floodwaters, the heating element would short-circuit and require replacement.

Further, floodwaters would cause silt or mud sedimentation within the components of any inundated furnace, i.e., the air intake, combustion chamber, blower, vent pipes, air ducts and pumps. Attempts to use the furnace with these materials within the components would be hazardous as it could cause short-circuits, fires, and/or improper/incomplete combustion.

Elevation

1. The most effective flood protection technique is to locate the furnace or boiler on a floor that is elevated above the DFE.

2. Elevation can also be achieved by using a lateral or in-line furnace that fits into the ductwork at any location above the DFE. Such furnace units usually include a blower. For cooling, an evaporator coil can be added to the same unit. *Figure 3.1.4A* shows a typical horizontal in-line furnace configuration.

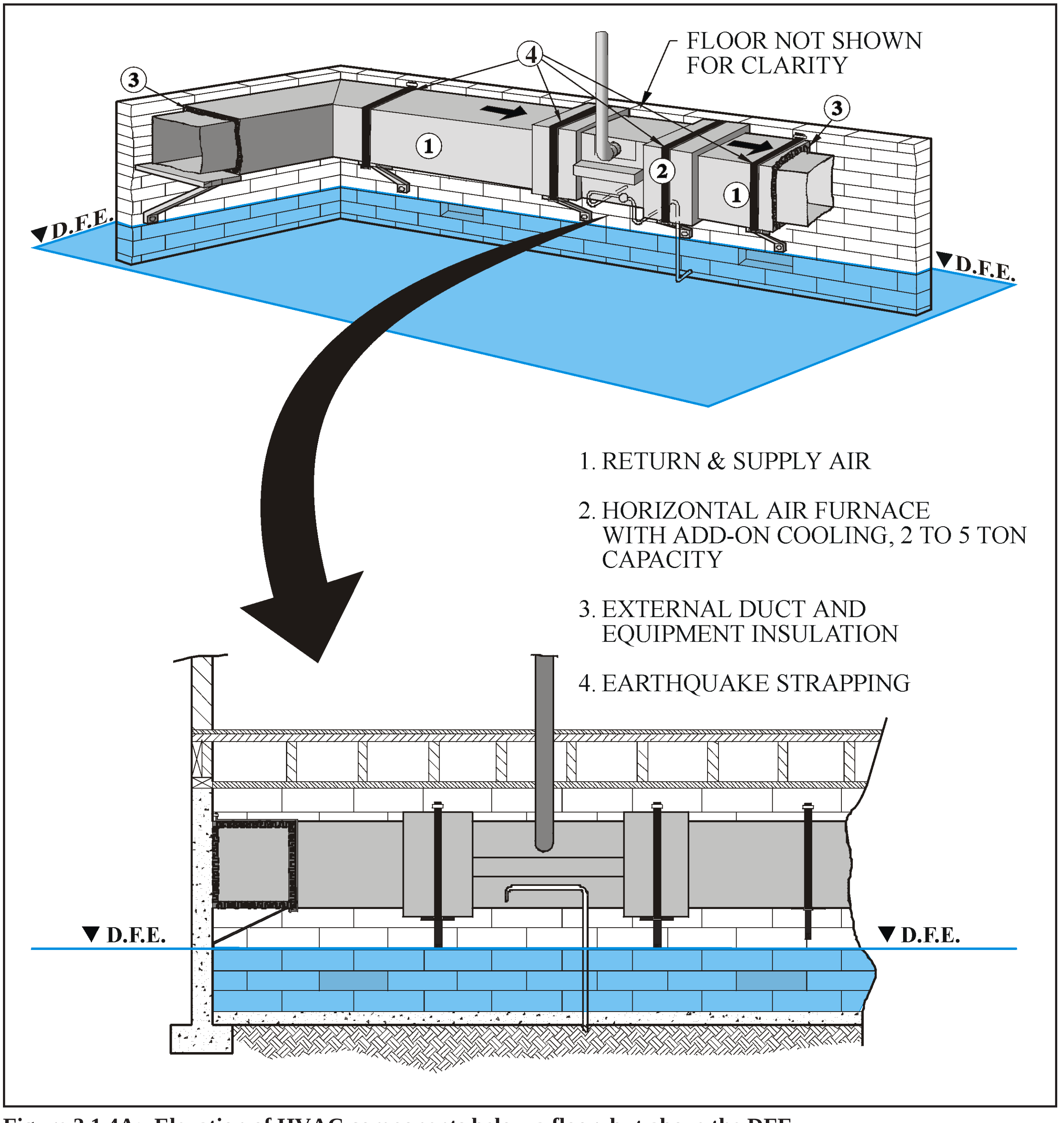


Figure 3.1.4A: Elevation of HVAC components below a floor, but above the DFE

3. A furnace, boiler, or water heater can be located in the attic to protect it from floodwater inundation. *Figure 3.1.4B* shows a furnace located in an attic.

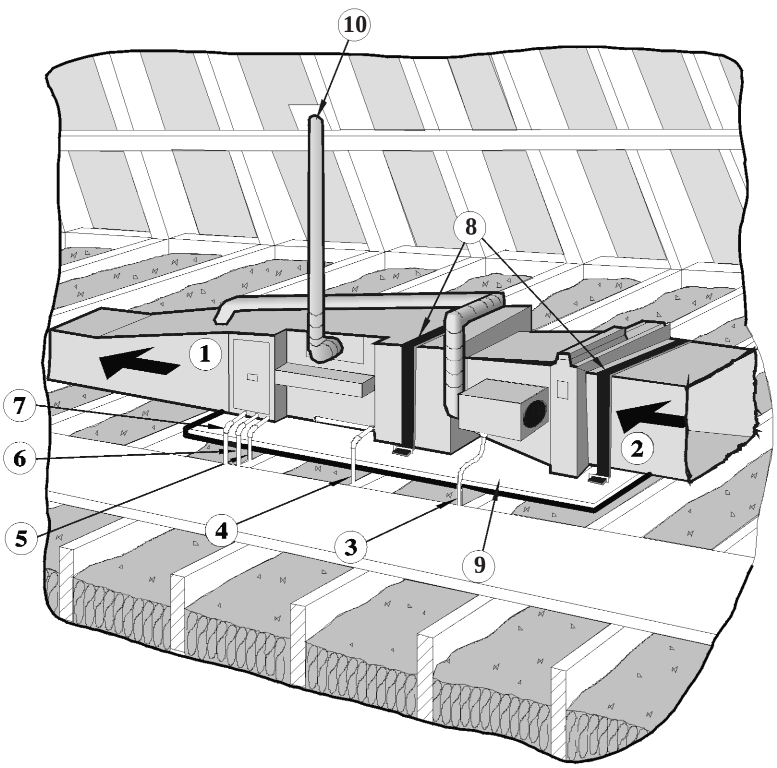


Figure 3.1.4B: Elevated furnace with cooling coil, electronic air cleaner, and automatic humidifier located in the attic

4. HVAC mechanical equipment can be located on a platform at or above the DFE even though the floor the platform is located on is below the DFE. The top of the platform must be above the DFE. *Figure 3.1.4C* shows pedestal- mounted mechanical equipment.

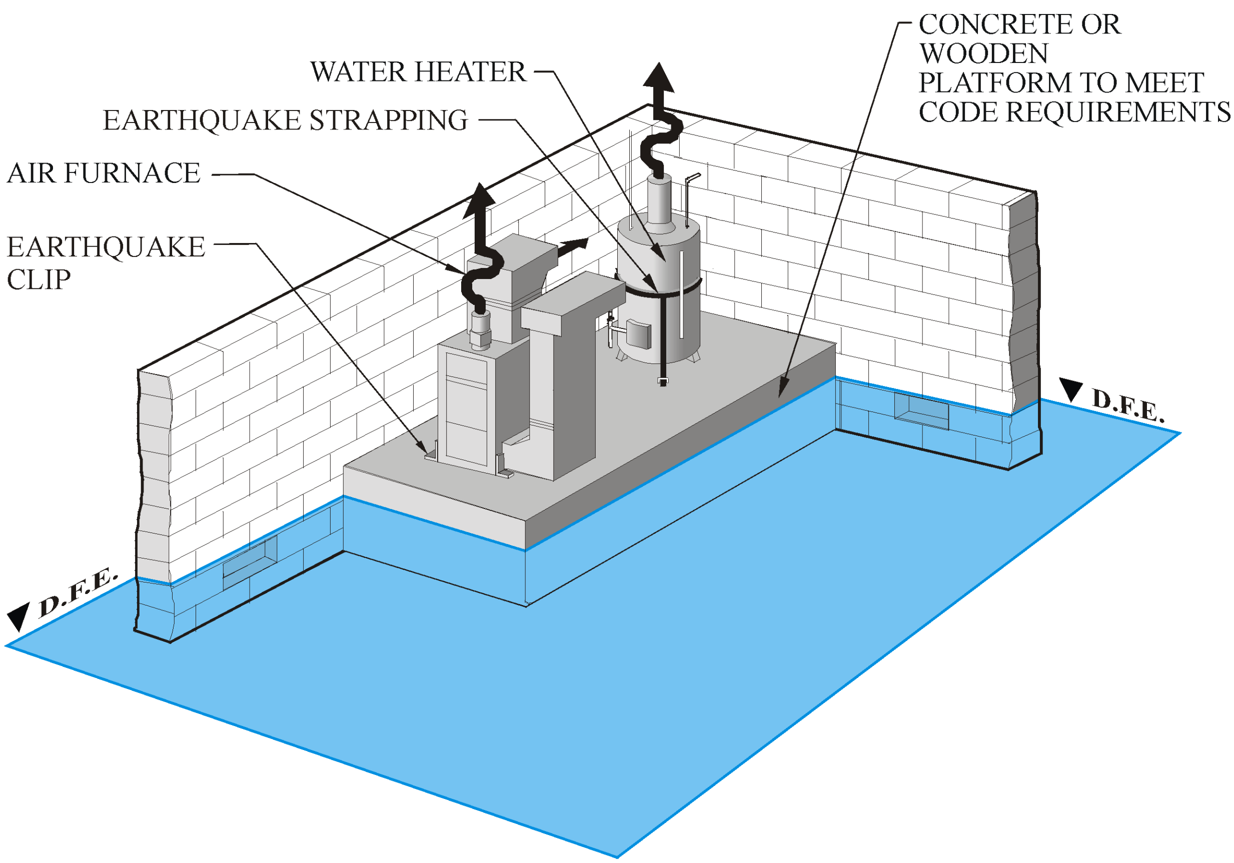


Figure 3.1.4C: Elevation of mechnical equipment on a platform in an area used only for storage, building access, or parking

Component Protection

Furnaces located below the DFE in A Zones can be enclosed within watertight walls that extend above the DFE. The walls, as shown in *Figure 3.1.4D*, must be strong enough to withstand hydrostatic forces. If the flood level is low enough, a low wall or curb can be constructed without a closure panel. The closure panel should be left latched except when servicing the equipment.

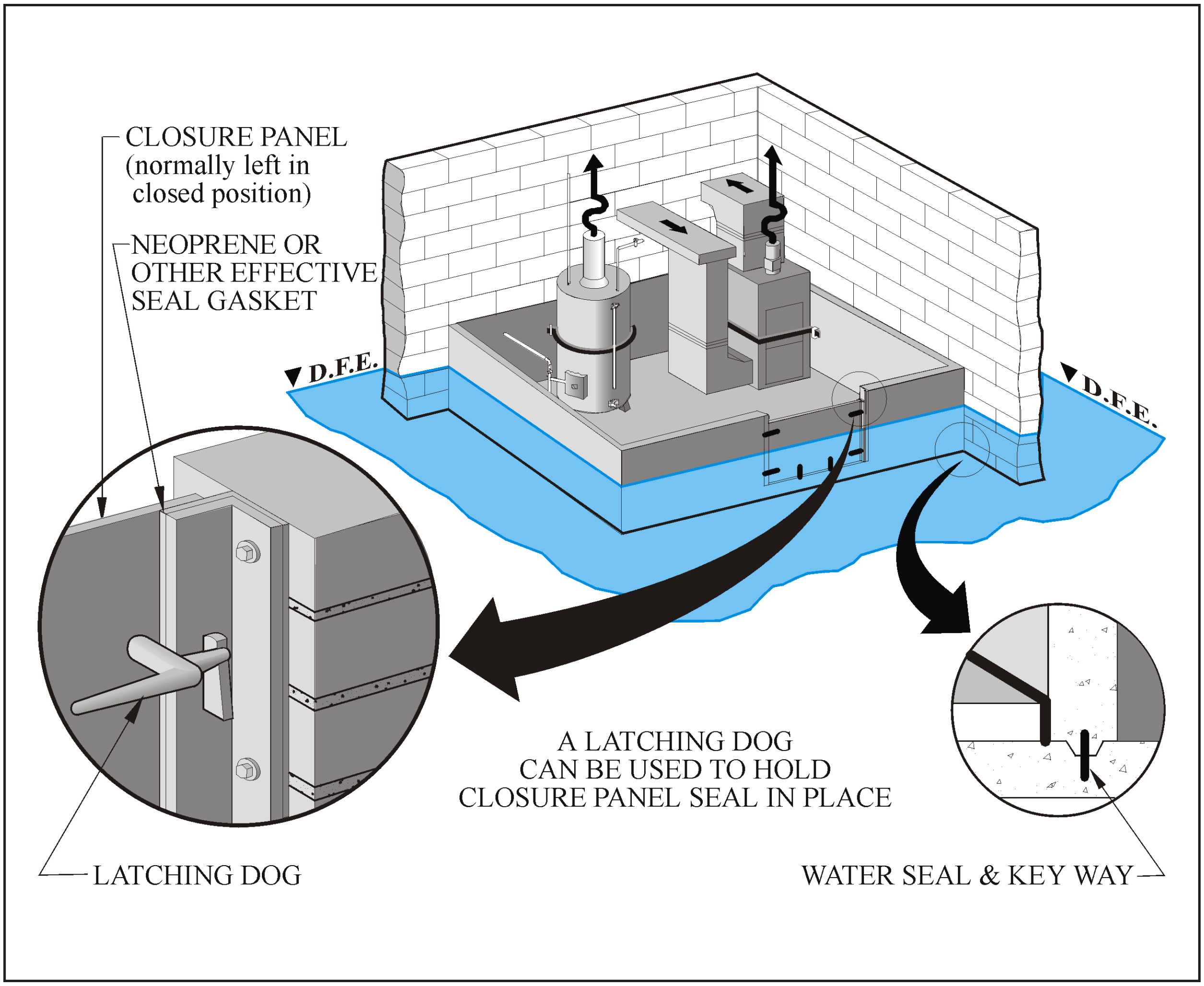


Figure 3.1.4D: Watertight enclosure of mechnical equipment in an area used only for building access, parking, or storage

Note that component protection using watertight walls is generally used when construction of platforms or pedestals is not feasible (for example, a water heater or other piece of equipment may be too tall to be elevated above the DFE and fit on a given floor). For flood protection of HVAC system equipment in new and substantially improved buildings, construction of pedestals generally provides a simpler and more cost-effective solution than watertight walls.

3.1.5 Supporting Distribution Systems

Supporting distribution systems include air ducts, hot water lines and electrical wiring. The hot water and electrical systems are also covered in sections 3.5 and 3.3, respectively. The NFIP requires that air ducts in HVAC systems be designed and/or located in structures in such a way that prevents water from entering or accumulating within the HVAC system components during base flooding conditions (See Section 2.5). The following problems are likely to occur when air ducts are inundated by floodwaters:

- Floodwaters may become trapped inside ductwork as flooding recedes. This often leads to the dislodging and collapse of the ductwork.
- Absorption of floodwaters by duct insulation adds more weight to the duct system than was considered in the design and installation which can result in failure of the support hardware as well as the duct itself. In addition, it is difficult and not cost effective to remove wet insulation embedded within the ducts.
- Accumulation of residue (grit, sand, mud, micro-organisms, farm chemicals, road oil, fecal material, and other contaminants) and mildew from flood waters in the duct system can cause odor and air contamination which can be a significant health hazard to the occupants of the structure.

Elevation

The most effective design strategy for air ducts is elevation above the DFE. This can be done by:

- Hanging the ducts from the bottom of the lowest floor or the crawl space ceiling so that the bottom of the duct is above the DFE. Refer back to Figure 3.1.1A for an example of this installation.
- Locating the ducts in the attic of the structure. This method minimizes the risk of inundation.
- Locating the ducts above a suspended ceiling.
- Locating the ducts within the habitable areas and concealing them with a bulkhead.

Locating ductwork below the DFE is not permitted unless it is designed and constructed so that floodwater will not enter or accumulate within the system components.

All controls and electrical components should be located above the DFE. These components are typically very expensive and are usually particularly susceptible to damage by floodwater inundation. Luckily, these components can usually be easily relocated above the DFE.

Component Protection

> **NOTE:**
> Component protection for duct work refers to continuous duct segments below the DFE which are watertight and terminate above the DFE. Duct segments with openings below the DFE or that terminate below the DFE are not permitted under the NFIP.

The NFIP does not recommend locating duct work below the DFE in any new or substantially improved structure located in an SFHA. There is no known cost-effective technique for designing air ducts to keep floodwater from entering or accumulating within the system components during inundation by floodwaters.

If duct work must be installed below the DFE, it should be minimized as much as possible. The material used for the ducts must be impermeable and watertight, such as welded seamless ductwork or large diameter PVC pipe. Such material is very expensive but practical for cases where a short length of duct work descends below the DFE.

The water and fuel piping associated with HVAC systems must be properly protected from damage during flooding. PVC piping generally requires special consideration when used in flood-prone areas. This type of pipe is more susceptible to impact breakage. In addition, the nature of the material sometimes fractures or shatters when exposed to the heaving and settling that a structure experiences when withstanding floodwaters. If the lines are ruptured, it may result in contamination, leaking, or even fire. In general, copper and galvanized metal piping is better suited for use in flood-prone areas.

3.1.6 Conclusion

The following figure and tables have been provided which summarize the overall design approach for flood resistant HVAC systems in new and substantially improved buildings. *Figure 3.1.6* is a flow chart that outlines the basic steps involved in the design of a flood resistant HVAC system. *Table 3.1.6* is a checklist to aid in the review of proposed designs or existing systems for compliance with federal, state, and local requirements. In addition, a sketch sheet is included so that the locations or details of the system can be noted. The tables are intended to assist designers and building officials in providing the most effective level of flood protection for HVAC system components.

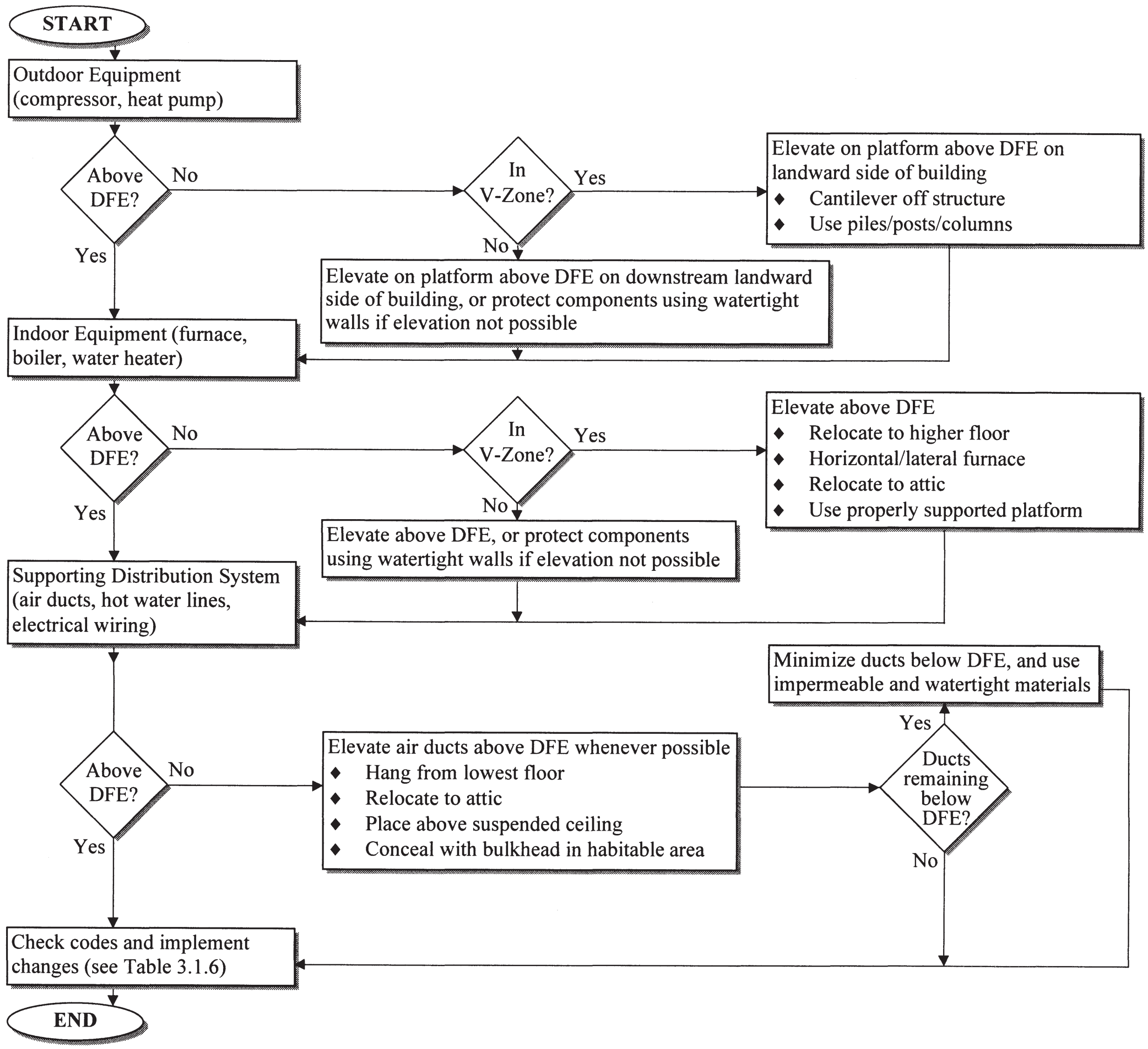


Figure 3.1.6: Steps involved in the design of a flood resistant HVAC system

FLOOD RESISTANT HVAC SYSTEM CHECKLIST

Property ID:	Property Contact:
Property Name:	Interviewed:
Property Address:	Phone:
Surveyed By:	Date Surveyed:
DFE:	
• What type of heating system is used? Elevation:	
☐ Natural Gas Piping type: Location of service entrance:	☐ Fuel Oil Piping Type: Tank Location:
☐ Electric Location of electrical service entrance:	☐ Other:
Description of Heating system:	
• What type of A/C system is used? Elevation:	
☐ Central Air Outside unit location/elevation: Inside unit location/elevation:	☐ Window units Location/elevation: Voltage:
Description of A/C system:	
• Does condensate drain above the DFE?	
• Are air intakes above the DFE?	
Location/elevation of electronic HVAC controls:	
Is any ductwork located below the DFE? ☐Yes; elevation: ☐ No Describe ductwork located below the DFE:	
What equipment is located beneath the DFE?	

☐ Heating Unit	☐ Outdoor Cooling Unit	☐ Indoor Cooling Unit	☐ Electronic Controls	☐ Ductwork	☐ Fuel Oil Tank

☐ Other:	☐ Other:

Table 3.1.6: Checklist to aid in the review of proposed designs for compliance with Federal, State, and local regulations

Sketch sheet
(for details, notes, or data regarding system installations)