
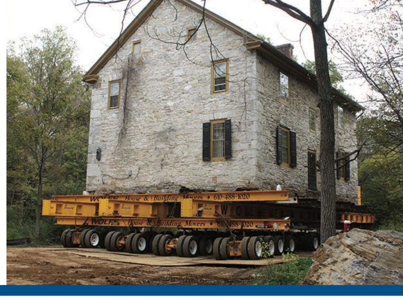

# 9.0 Protecting Service Equipment

Homes are typically provided with a variety of building support service equipment. Five major services make up the mechanical, electrical, and plumbing (MEP) systems found in most homes:

- HVAC systems, including air conditioning compressors, heat pumps, furnaces, ductwork, and
- Fuel systems, including natural gas lines and fuel storage tanks
- Electrical systems, including wiring, switches, outlets, fixtures, and fuse and circuit breaker panels
- Sewage management systems, including sewer lines, drains, septic tanks, and drainage fields
- Potable water systems, including water lines, private wells, storage tanks, and water heaters

Most homes also have communications systems, including telephone, internet, and cable television lines.

> **CROSS REFERENCE**
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> For more information about elevating electrical and HVAC systems, refer to FEMA 348, *Protecting Building Utilities from Flood Damage* (1999), Hurricane Sandy Recovery Advisory No. 3, *Restoring Mechanical, Electrical, and Plumbing Systems* (2013), and FEMA 499, Fact Sheet No. 8.3: *Protecting Utilities* (2010).

Some MEP equipment is typically located inside a home (e.g., furnaces, ductwork, water heaters, appliances) and some is located outside (e.g., propane tanks, air conditioning and heat pump condensers, septic tanks). Other MEP equipment includes components found both inside and outside a home (e.g., electrical systems; plumbing, gas, telephone, internet, and cable television lines; oil storage tanks).

The original placement of service equipment in and around your home was probably based on standard construction practices and the builder's preferences. As a result, service equipment is often installed in areas where it will be exposed to floodwaters, such as in a basements or crawlspaces or at ground level outside the home.

Elevation, wet floodproofing, and dry floodproofing protect the structure of your home from damage by floodwaters. But these methods, unlike relocation and the construction of levees or floodwalls, do not prevent floodwaters from reaching the home. For this reason, protecting service equipment located below the expected flood level is an essential part of a retrofitting project.

When relocating or elevating MEP systems, consider horizontal and vertical clearances; venting; and unions, fittings, and valves. The replacement of MEP systems also presents an opportunity to improve the energy efficiency of your house by selecting high-efficiency equipment that may not have been available when the damaged equipment was installed.

If your house has been damaged by a flood, the repair and restoration work must not violate any floodplain management requirements in effect when the house was originally built. Always check with your local building department, as locally enforced codes may differ from what is described in this chapter. For example, some communities may require all MEP system restoration or alteration work to comply with the applicable sections of the current code, even in houses that are not Substantially Damaged. When considering relocating or elevating MEP systems, follow all applicable codes, regulations, and manufacturers' installation requirements.

### Flood Insurance Implications

Houses built after communities joined the NFIP were required to be elevated to or above the BFE to minimize flood damage. These houses should already have elevated MEP systems and components. However, if some equipment was not elevated (such as a furnace or ductwork located in a crawlspace), owners may be paying much higher NFIP flood insurance premiums than necessary. Replacing damaged equipment and elevating it on platforms not only minimizes future damage, but may lower flood insurance premiums. Check with insurance agents to find out whether taking this action will affect your flood insurance premiums.

You can protect interior and exterior service equipment in three ways: elevating it, relocating it, or protecting it in place. More information on these methods can be found in FEMA 348, *Protecting Building Utilities from Flood Damage* (1999).

## 9.1 Elevation

Service equipment installed outside your home can usually be elevated above the flood level. Equipment mounted on an exterior wall (e.g., an electric meter, incoming electric, telephone, and cable television lines) usually can be mounted higher up on the same wall. Equipment typically placed on the ground (e.g., air conditioning compressors, heat pumps) can be raised above the flood elevation on pedestals or platforms (Figures 9-1 and 9-2).

When you elevate service equipment, you should always consider raising it at least 1 foot above the BFE, just as when you protect your home with one of the methods described in this guide. Elevating service equipment an additional 1 or 2 feet often will not increase your retrofitting costs significantly but will provide an extra measure of flood protection. Since gas and electric meters are typically owned by a utility company, you may not be allowed to move or elevate them without the utility company's permission.

**NOTE**

Some utility companies have requirements for ensuring their meter readers can access the meters, such as providing stairs to a platform under the reader. Check with your service provider before elevating service equipment. Refer to the Hurricane Isaac Recovery Advisory No. 2, *Minimizing Damage to Electrical Service Components* (2012).

Figure 9-1. Air conditioning / heat pump compressor mounted on a brick pedestal outside an elevated home.

Figure 9-2. Air conditioning/ heat pump compressor mounted on a cantilevered platform attached to a home elevated on an open foundation. (Source: FEMA P-55 Figure 12-2)

The feasibility of elevating equipment inside a basement or garage depends largely on the flood level. Simply raising the equipment above the floor using a solid pad (such as masonry or concrete) or a framed platform (wood or steel) may be possible. Outdoor equipment can be elevated on a platform attached to the side of the house. The materials selected to construct elevated platforms should meet the requirements described in NFIP Technical Bulletin 2, *Resistant Materials Requirements* (2008), and should be non-combustible when required by the code. A pad should be properly anchored to the floor system or slab, and the equipment should be properly anchored to the pad.

**NOTE**

When elevating HVAC and other equipment, be sure to leave sufficient space around the unit to allow access for maintenance work.

As the height of the flood level increases above the floor, the amount of space available above the flood level diminishes and elevation is feasible only for smaller pieces of equipment (e.g., electrical system components, ventilation ductwork, or specialized equipment such as furnaces designed to be suspended from the ceiling). If the flood level is at or near the ceiling, elevation may not be possible. Instead, equipment must be relocated or protected in place as described in Section 9.3.

Keep in mind that most service equipment must remain accessible for routine maintenance. For example, your fuel company must be able to reach your fuel tank to fill or empty it. Before elevating any service equipment, check with the utility company to find out whether it has any requirements that would prohibit elevation or restrict elevation height.

Also, remember that any large equipment elevated on platforms or pedestals, both inside and outside your home, may be more vulnerable to wind and earthquake damage and may require additional bracing or anchorage. A design professional must determine the expected wind and earth¬quake forces at the site and account for them in the elevated platform design.

This precaution is especially important for elevated fuel storage tanks, which could rupture if they are dislodged or toppled by wind and earthquake forces. In earthquake-prone areas, fuel storage tanks are sometimes equipped with cutoff valves that can help prevent leaks when supply lines are ruptured. Your utility service provider can give you more information about cutoff valves and other ways to protect fuel storage tanks from natural hazards.

### 9.1.1 Maintaining Horizontal and Vertical Clearances

When moving equipment, either to another floor or elevated on a platform, maintain the recommended horizontal and vertical clearance around it as required by building codes and the National Electrical Code or as recommended by manufacturers. Minimum clearances required for equipment, conduits, piping, and duct work should be considered before relocating or elevating equipment. Designing for the minimum clearance is important to maintain air circulation, meet insurance or code requirements related to distance from combustible building materials, and provide space for maintenance. Most codes dictate that clearance requirements should follow those specified on the equipment label or installation instructions. Required clearance typically ranges from 6 to 36 inches, and can sometimes be reduced by installing heat shields if allowed by the building code. The use of a heat shield or other method to reduce clearance should be verified in codes and manufacturers' installation requirements. Failure to maintain proper clearance can result in safety issues, including fire, and can void equipment warranties.

### 9.1.2 Venting Considerations

Oil- or gas-fueled boilers, furnaces, and water heaters require adequate combustion air and venting of exhaust gases. Although some units may vent exhaust directly out of the unit through an exterior wall, other units may need to vent exhaust through a chimney. The type of venting system and the clearances necessary for the venting system may affect how high the equipment can be elevated.

The venting system should be tested to ensure it draws adequate air and backdrafting does not occur. If relocating equipment, consider the required venting system, as it may affect the final placement of the unit.

### 9.1.3 Unions, Fittings, and Valves

When relocating or elevating equipment is not feasible, consider replacing unions, fittings, or valves to allow faster replacement of equipment when damaged, or disconnecting equipment prior to a flood event and relocating it to a higher floor. Although this approach will not bring a non-conforming building into compliance with NFIP requirements, it may reduce potential flood damage to utility systems.

## 9.2 Relocation

When space permits, you can move service equipment from a basement or other area below the flood level to an upper floor of the home or even an attic. Relocation usually requires more extensive changes to both your home and the equipment being moved, but it often provides a greater level of flood protection because the relocated equipment is farther above the flood level. In some situations, you may also be able to relocate outside equipment to higher ground, but only when the slope of your lot and other site conditions permit.

**CROSS REFERENCE**

Chapters 3 and 4 of FEMA 348, *Protecting Building Utilities from Flood Damage* (1999), discuss relocation of service equipment in detail.

Another relocation option is to build a new, elevated utility room as an addition to your home. The addition could be built on an open foundation or extended foundation walls.

Relocating and elevating equipment and systems can be a simple process, such as elevating a water heater on a small platform, or a complex process involving relocating equipment to a higher floor or to a new addition built specifically as a utility room. Each type of system has specific vulnerabilities, characteristics, and restrictions on placement that can affect a homeowner's ability to relocate it.

### 9.2.1 Electrical Panels

Power outages after a flood event often last much longer if a house's electrical panel is located below the flood elevation because the panel must be replaced before power can be restored. To address this problem, the electrical panel should be relocated to an elevation above the lowest floor (into the living space). When moving electrical panels to an elevation above the lowest floor, additional components, such as a service disconnect, may need to be incorporated into the system to meet the requirements of the National Electrical Code. Also, when relocating electrical panels, codes or local requirements may require replacing significant portions of the house wiring. For additional information on relocating electrical systems, consult Hurricane Isaac Recovery Advisory No. 2, *Minimizing Damage to Electrical Service Components* (2012).

### 9.2.2 Electric Meters

Damage to electrical meters is common during flood events. Relocating meters can often result in reduced outage times following flood events. Although some electric utility companies allow meters to be relocated, they often have specific requirements and specifications. Most electric utility companies do not want their employees to be put at risk climbing ladders or stairs. You may be able to work with your electric utility company to find an appropriate spot to relocate your meter to reduce the risk of it being damaged by floodwaters.

### 9.2.3 Electrical Wiring

In many houses, some wiring is located below the BFE, especially where the utility service is routed underground. If wiring is located below the BFE and the wiring is not rated for wet locations, the wiring should be encased in a non-corrosive metal or plastic pipe (conduit) when allowed by code. The conduits should be installed vertically to promote thorough drainage when floodwaters recede. Damaged wiring is easier to replace if it is installed in a conduit.

### 9.2.4 Mechanical Systems

Mechanical systems include the HVAC system, duct work, and the air handler that delivers the conditioned air throughout the house. Elements of the heating and cooling system below the BFE are subject to flooding. Ductwork beneath a house's floor system is susceptible to flooding and should be removed and replaced if it is inundated by floodwaters. The ductwork connected to the furnace and air handler is often the most prone to flood damage because the furnace is often located in the basement or the building's lowest floor.

In many instances, elevating mechanical systems above the BFE may not be possible. They should still be elevated as high as possible. Relocating mechanical equipment may require replacing ductwork and moving electrical supplies and refrigerant lines. Physical obstructions, such as walls or framing, may restrict the relocation of ductwork and the final location of the system components.

**Condensing units.** Protecting the condensing unit for an air conditioning system can often be achieved by elevating it on a platform or attaching a platform to the side of the house. A cantilevered platform is preferred over a platform on posts. Posts can obstruct floodborne debris and are more vulnerable to damage and failure, including floodborne debris impacts and undermining by scour and erosion.

**Heating systems.** Boiler systems, which are typically oil- or gas-fired, heat water and either force hot water or steam through radiators or baseboards throughout the home. A hot water boiler system consists of the main boiler, heat exchanger and burner, circulation pumps or control valves, and an expansion tank. Many components of a boiler system can be damaged by contact with floodwaters. Protecting a boiler system from flooding usually requires raising the system in its entirety. Although most boiler systems in residential use are hot water systems, the protection of a steam boiler is similar. Relocating a boiler system to an upper level is ideal, but can present some significant challenges, such as needing to reroute the plumbing associated with the system. Elevating the boiler as high as possible on its current floor may be more practical. The main concerns when elevating a boiler are clearances, venting the exhaust, and protecting the supply tank from contamination. Systems using heating oil rely on either an above- or below-ground storage tank. The storage tank should be properly anchored and sufficiently sealed to prevent floodwater from contaminating the heating oil or allowing the oil to be released.

A furnace or forced air heating system uses oil or natural gas (and sometimes electricity) to heat air blown across heating coils in the system. Relocating these systems to upper floors or attic areas may be possible. If elevating the furnace to an upper floor is not possible and elevating the furnace in its existing location below the living area is the only practical mitigation measure, the required clearances and venting of the unit must be accommodated.

### 9.2.5 Water Heaters

Water heaters, which are oil- or gas-fired, are powered from an electric coil. Conventional residential water heaters that use storage tanks typically range in capacity from 40 to 80 gallons. When exposed to floodwater, the internal components of the water heater can be damaged.

**Electric water heaters.** In some buildings, electric water heaters can be relocated to a higher floor or the attic. Relocating the unit requires plumbing and electrical work, as well as a method to drain the tank and prevent water damage from leakage. Although relocating a water heater to the attic effectively protects it from flood damage, the heater must be equipped with a drain pan and drain to avoid costly water damage in the event of leakage. If a water heater is placed in an attic, it should be routinely maintained and inspected for leaks or other problems.

**Oil or gas-fired water heaters.** Oil- or gas-fired water heaters must be vented and may, therefore, be difficult to move into a main living space. If an appropriate location for the water heater is not available on a higher floor, it can potentially be elevated in its current location. Elevating the tank usually requires a small pad or platform, an appropriate location to vent the exhaust, and extending or shortening water supply lines and distribution lines.

**Other water heaters.** Although more expensive than conventional water heater systems, tankless systems, which heat water instantaneously, require significantly less space and may present a flood mitigation opportunity because of their smaller size. Converting a conventional water heater unit fueled by natural gas to a tankless system requires minimal additional work. Electric tankless water heaters, by comparison, may not be practical because of the electrical system upgrades needed in some houses to provide the additional electrical power for the water heater.

Although moving equipment into the attic area may appear to be an effective use of space, equipment such as water heaters can cause problems if they are not properly installed. Drain pans and piping to address a water heater leak must be carefully considered to make sure water will not overflow and damage rooms below. In areas subject to freezing temperatures, drain lines could freeze and prevent water from draining, causing significant interior water damage.

### 9.2.6 Washer/Dryer Units

Many washing machines and clothes dryers are located in basements, where they are vulnerable to flooding. Relocating this equipment to a higher floor may not be practical if space is limited in the living area. Even minimal elevation may prevent the units from being damaged in low-level flooding situations. A permanent pad or platform should be constructed to elevate these units; stacked bricks or blocks should not be used because they can shift and result in injuries to users or damage to the equipment. Elevating washing machines and clothes dryers may require altering the water and drain piping, electrical connections, and gas connections.

## 9.3 Protection in Place

When elevation and relocation are infeasible or impractical, you may be able to protect service equipment in place with low floodwalls and shields and with anchors and tie downs that prevent flotation. Plumbing systems can be protected with valves that prevent wastewater from backing up into the home.

### 9.3.1 Floodwalls and Shields

Floodwalls and shields are typically components of dry floodproofing systems (Chapter 7) that are used to protect entire buildings. However, if a building is wet floodproofed, these components can be used for the protection of small areas within a building that contain service equipment that cannot be elevated or relocated. For example, you can build a concrete floodwall that surrounds one or more pieces of service equipment, such as a furnace and water heater (Figure 9-3).

If the expected flood depth is less than about 12 inches, the floodwall could be low enough that you could step over it to reach the protected equipment. A higher floodwall can include an opening equipped with a removable shield, as shown in Figure 9-3, to permit easy access to the protected equipment. In this example, the shield does not interfere with the normal operation of the equipment, so it should be left in place and removed only when necessary to service the equipment. Leaving the shield in place allows the barrier to function without human intervention.

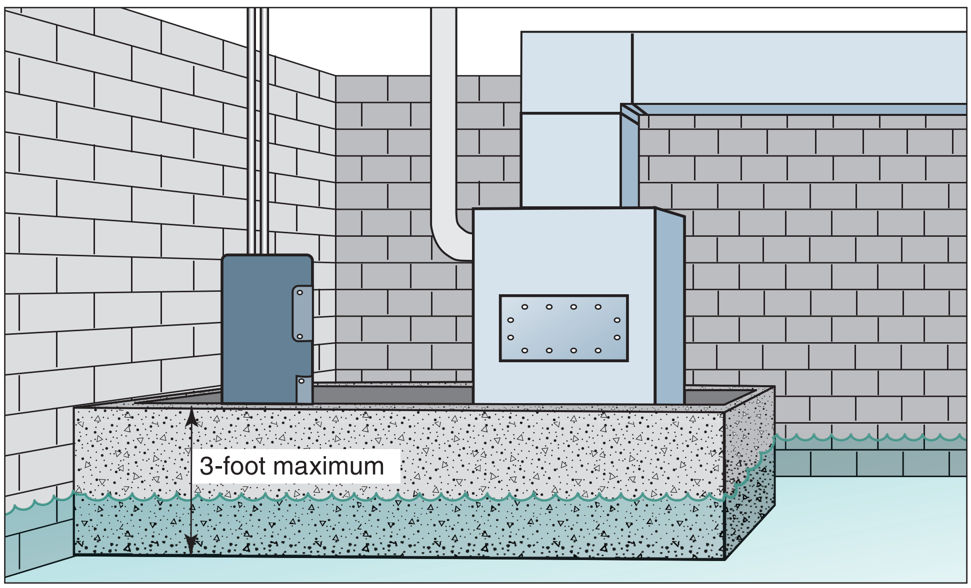


**Figure 9-3. Water heater and furnace protected by a concrete floodwall with opening and gasketed shield.**

In general, barriers and shields of the type shown in Figure 9-3 are practical only when flood depths are less than about 3 feet. The greater hydrostatic pressure exerted by deeper water requires barriers and shields that are more substantial, have more complex designs, and are, therefore, more expensive. As discussed in Chapter 8, all floodwalls should provide at least 1 foot of freeboard above the expected flood elevation.

Regardless of the height of the barrier, the area it protects should be equipped with a sump pump that will remove any water that accumulates through seepage.

### 9.3.2 Anchors and Tiedowns

Anchors and tiedowns are used primarily for aboveground storage tanks (ASTs) that are not el-evated above the flood level and for underground storage tanks (USTs). Both types of tanks are extremely vulnerable to flotation. Floodwaters and debris impact forces act directly on ASTs, and USTs can be forced out

**CROSS REFERENCE**

For more information about anchoring fuel storage tanks, refer to FEMA 348, Protecting Building Utilities from Flood Damage (1999), and the FEMA Fact Sheet series *Protect Your Property from Flooding, Anchor Fuel Tanks* (2011).

of the ground by the buoyancy force of saturated soils. When either type of tank is displaced, its connections can be severed and the escaping fuel can cause hazardous conditions.

ASTs can be anchored with metal straps or cables that cross over the tank and connect to ground anchors. The length and type of ground anchor you need depends largely on the type of soil at the site. A design professional can advise you about anchors. Another way to anchor an AST is to embed its legs in a concrete slab (Figure 9-4).

Ground anchors can also be used for USTs. The anchoring method involves excavating the soil above the tank, placing steel I-beams across it, and connecting them to ground anchors. Again, check with a design professional concerning the required size and type of anchor. USTs can also be anchored with a concrete slab similar to the one shown in Figure 9-4. Installing the slab involves excavating around the tank and removing it temporarily while the slab is poured. Another alternative is to excavate down to the tank and pour a concrete slab on top, ensuring not to cover access openings.

**NOTE**

Be especially careful when anchoring storage tanks or other service equipment in floodways, Zone V areas, and other high-risk areas. Consider the effects of high-velocity flows, wave action, fast moving floodborne debris, and extensive erosion and scour wherever these hazards are likely to occur.

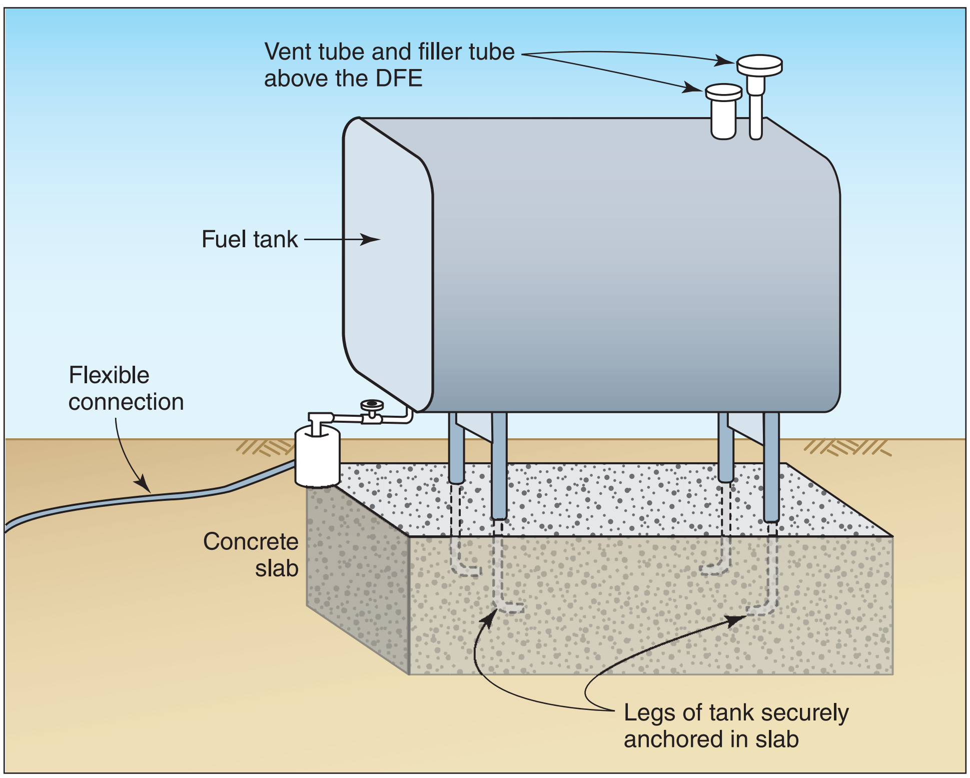


**Figure 9-4. Anchoring a fuel storage tank with a concrete slab.**

On all tanks below the flood level, both aboveground and underground, flexible connections must be used between the tank and the supply line. Also, the vent and filler tubes must extend above the flood protection elevation (Figure 9-4). If you have adequate warning of an impending flood, top off the tank. A full tank will be less susceptible to corrosion from accumulated moisture and will be heavier and better able to resist buoyancy.

Although anchoring is particularly important for storage tanks, remember that the levels of future floods can rise higher than expected and inundate service equipment that you have elevated, relocated, or protected in place. For this reason, service equipment should be anchored whenever possible so that it will remain in place when acted on by flood forces. Anchorage systems should be designed assuming a worst-case scenario of an empty tank.

### 9.3.3 Backflow Valves

Flooding can inundate and overload sanitary sewer systems and combined sanitary/storm sewer systems. As a result, water can flow backward through sewer lines and out through toilets or drains. The best solution to this problem is usually to install a backflow valve. These valves include check valves, gate valves, and dual backflow valves.

> **WARNING**
>
> The installation of backflow valves and other plumbing modifications is usually regulated by State and local building codes. Some municipalities may prohibit the use of backflow valves. A plumber or contractor licensed to work in your area will know about the code requirements that apply to your retrofitting project.

Check valves operate without human intervention. Under normal conditions, they allow wastewater to flow from the home to the main sewer line. When flooding causes the flow to reverse, a flap or other check mechanism in the valve prevents water from flowing back into the home. A disadvantage of check valves is that they can become blocked open by debris and fail to operate. For this reason, check valves must be inspected regularly and cleaned as necessary.

Gate valves are manually operated, provide a better seal, and are unlikely to be blocked open. However, they are more expensive than check valves and require human intervention.

The third alternative is dual backflow valves, which combine the benefits of the check valve and the gate valve. As the most expensive of the three valve types, the dual backflow valve should be considered primarily for use in homes subject to repeated backflow flooding. Gate valves and dual backflow valves are usually installed outside the home in a valve pit (Figure 9-5). A licensed plumber should install any check valve system in compliance with local codes. Some current community codes only allow use of dual check valve systems.

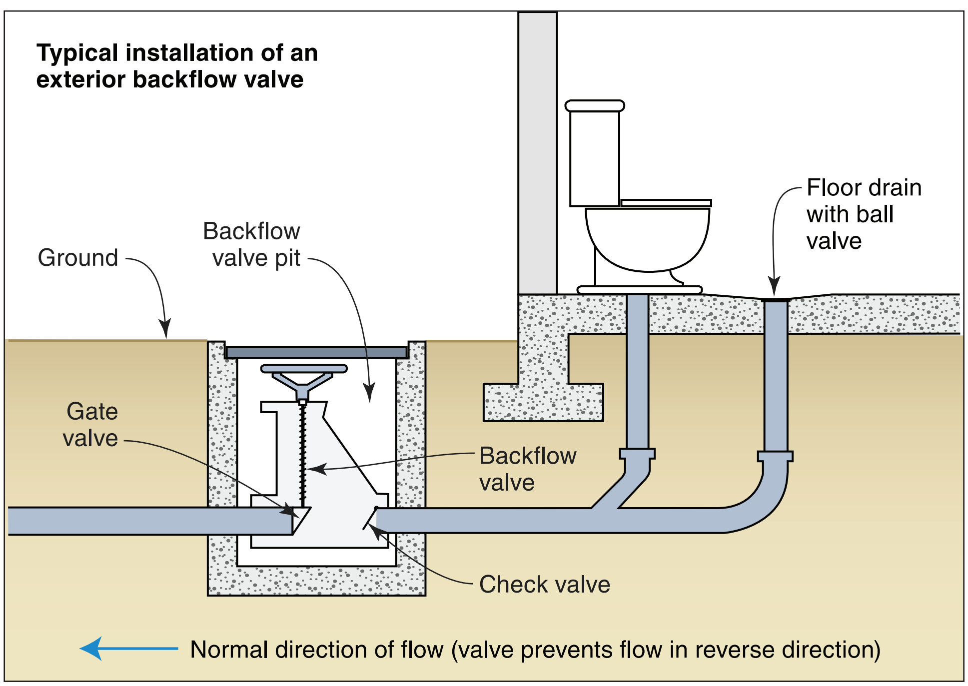


**Figure 9-5. Example of an exterior backflow valve installed in a valve pit.**