Restoring Mechanical, Electrical, and Plumbing Systems

In Non-Substantially Damaged Residential Buildings

FEMA

HURRICANE SANDY RECOVERY ADVISORY *RA3, April 2013*

Purpose and Intended Audience

The Federal Emergency Management Agency (FEMA) deployed a post-disaster assessment teams to observe building damage in New York and New Jersey after Hurricane Sandy. The Team noted numerous residential buildings where mechanical, electrical, and plumbing (MEP) systems (called "utility systems" in this Recovery Advisory) located on the ground or below-ground level were severely damaged by floodwaters (Figure 1). The damage was particularly severe for equipment located in basements, below-grade (ground) garages, crawlspaces, and at-grade storage areas near shorelines or areas subject to storm surge or riverine flooding. The purpose of this Recovery Advisory is to describe methods to restore utility systems in a manner that minimizes damage from future flood events and reduces the system restoration time following future storms. The intended audience for this Recovery Advisory is homeowners and the information is solely for residential buildings.

Figure 1: A water heater and furnace system damaged by Hurricane Sandy floodwaters (Beach Haven, NJ)

Many of the houses observed to have severely damaged utility systems may not have received Substantial Damage. This Recovery Advisory addresses houses that were not Substantially Damaged during Hurricane Sandy and are not undergoing Substantial Improvement. Repair and restoration work on these houses must be done in a manner that will not violate any floodplain management requirement in effect when originally built. Homeowners should always check with local building departments, as locally

Terminology

Substantial Damage: Defined by the National Flood Insurance Program (NFIP) as "damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred."

Substantial Improvement: Defined by the NFIP as "any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the 'start of construction' of the improvement. This term includes structures that have incurred 'Substantial Damage,' regardless of the actual repair work performed."

Refer to FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010) for more information. Homeowners should consult a local building official to determine whether their local codes and regulations have more restrictive definitions.

enforced codes may differ from what is described in this Recovery Advisory. For example, some communities may require all utility 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 systems, all applicable codes, regulations, and manufacturers' installation requirements should be followed.

Background information on the general requirements of the National Flood Insurance Program (NFIP) is provided so homeowners can understand what actions are allowed and which actions will help increase their home's flood-resistance. The remainder of this advisory describes how to protect utilities in homes, including the specific NFIP requirements related to utility systems.

Key Issues:

1. Utility systems in many houses are located in areas at or below grade.
2. Severe flood damage to those utility systems was observed.
3. Homeowners may have limited ability to relocate utility systems due to the proximity of surrounding houses and internal space restrictions.

This Recovery Advisory Addresses:

- General NFIP background
- General mitigation considerations for residential utility systems
- Considerations for specific equipment and systems
- NFIP requirements for utility systems
- Useful links and resources

Evaluation, repair work, and installation of utility systems should be done by qualified, licensed contractors to ensure they are installed safely and in compliance with codes.

Terminology

Flood Insurance Rate Map (FIRM): A map produced by FEMA to show flood hazard areas and risk premium zones. The SFHA and BFE are both shown on FIRMs.

Special Flood Hazard Area (SFHA): Land areas subject to a 1 percent or greater chance of flooding in any given year. These areas are indicated on FIRMs as Zone AE, A1-A30, A99, AR, AO, AH, V, VO, VE, or V1-30. Mapped zones outside of the SFHA are Zone X (shaded or unshaded) or Zone B/Zone C on older FIRMs.

Base Flood Elevation (BFE): Elevation of flooding, including wave height, having a 1 percent chance of being equaled or exceeded in any given year (also known as "base flood" and "100-year flood"). The BFE is the basis of insurance and floodplain management requirements and is shown on FIRMs.

General NFIP Background

NFIP requirements apply to buildings in regulatory floodplains, also called Special Flood Hazard Areas (SFHAs).[1] Although NFIP requirements only apply to buildings in an SFHA, the guidance in this Recovery Advisory is also applicable to buildings in areas outside of the SFHA where flooding is a concern. For houses in the SFHA, the NFIP regulations restrict the use of areas located below the base flood elevation (BFE). Allowable uses are vehicle parking, building access (e.g., foyers and stairwells), and storage. The following items are not allowed below the BFE because they may be damaged and their presence is inconsistent with allowable uses: appliances, heating and cooling equipment, and plumbing fixtures. Electrical equipment and wiring is permitted below the BFE only if needed to satisfy life safety and electric code requirements for the allowable uses as long as it meets the code requirements for wet locations.

Following large storm events, such as Hurricane Sandy, FEMA may perform an assessment to determine whether the 1-percent-annual-chance flood event, shown on the Effective Flood Insurance Rate Maps (FIRMs), adequately reflects the current flood hazard. The resulting Advisory Base Flood Elevations (ABFEs) are provided to communities as a tool to support recovery and future resiliency. Communities must use ABFEs when designing recovery or mitigation activities funded using FEMA grants (e.g., Public Assistance or Hazard Mitigation Grants).

1 Communities adopt and enforce flood provisions in order to participate in the National Flood Insurance Program (NFIP).

ABFEs and BFEs

FEMA recommends that communities apply the adopted ABFEs to new construction, buildings undergoing Substantial Improvements, and Substantially Damaged structures to ensure that construction is built stronger, safer, and less vulnerable to future flooding events.

Construction and repair of buildings in communities that have adopted ABFEs must use the revised elevation in place of the BFE shown on the Effective FIRM.

Post-Hurricane Sandy ABFE maps are available for parts of New York and New Jersey at http://www.region2coastal.com/sandy/abfe. FIRMs for all other participating communities are available at https://msc.fema.gov.

General Mitigation Considerations for Residential Utility Systems

Homeowners with damaged utility systems should consider elevating those systems while they are being repaired or replaced in order to minimize future flood damage. This subsection describes general mitigation considerations related to mitigating utility systems; specific considerations for different types of equipment (electrical panels, mechanical systems etc.) are described in the following subsection. When relocating or elevating utility systems, homeowners need to consider horizontal and vertical clearances; venting; and unions, fittings, and valves. The replacement of utility systems also presents an opportunity for homeowners to improve the energy efficiency of their houses by selecting high-efficiency equipment that may not have been available when the damaged equipment was installed.

FEMA recommends that all utility systems be elevated to the BFE or higher, though it may not be specifically required for houses that are not Substantially Damaged. Table 1 shows FEMA recommendations for elevating or relocating equipment based on the location of the home with respect to the SFHA. When elevating equipment to the recommended elevation is either not possible or cost-prohibitive, FEMA recommends protecting equipment by moving it to a location on or above the lowest living space floor.

Table 1. Recommended Equipment Elevations

Location of House	Recommended Elevation for Equipment
Inside SFHA, as mapped on Effective FIRM	Elevate to BFE or ABFE, whichever is higher
Outside SFHA, but inside Advisory Flood Zone A or V (defined on ABFE map)	Elevate to ABFE
Outside SFHA and outside Advisory Flood Zone A or V (defined on ABFE map)	Elevate to the nearest ABFE or lowest living area that was not flooded, whichever is higher

SFHA = Special Flood Hazard Area
BFE= base flood elevation
ABFE = Advisory Base Flood Elevation

Figure 2: Coastal house with a below-grade garage and storage area, which typically contain utility systems. These areas are subject to flooding (Manhattan Beach, Brooklyn, NY).

Relocating Equipment

If there is insufficient space on a higher floor, a homeowner may choose to build an elevated addition to the house to be used as a utility room. Moving equipment to a higher floor is particularly important for houses where the equipment is currently in basements and below-grade garages (Figure 2).

If equipment cannot be relocated to a higher floor or a utility room cannot be added, the equipment should be raised as high as possible in its current location. However, homeowners should understand that simply elevating equipment in basements and below-grade garages may have limited success in reducing flood

damage. Many houses with below-grade garages have sump pumps to remove rainwater that enters from the adjacent ground or down the driveway. For houses near the coast, however, the volume of floodwater from storm surge will likely exceed the capacity of any residential sump pump, causing deep flooding in any below-grade space. For houses located away from the coast and subject to flooding from rainwater only, sump pump systems are less likely to be overwhelmed; in these situations, placing equipment as high as practical on elevated platforms in walkout basements or sub-grade garages may be effective.

Elevated Platforms and Anchorage

A common method of improving flood resistance of heating and cooling equipment is to elevate equipment and components so the equipment is above flood levels. In such cases, indoor equipment is not moved to a different floor but simply raised above the floor using a solid pad (such as masonry or concrete) or a framed platform (wood or steel) (see Figure 3). 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 for being resistant to flood damage as described in FEMA Technical Bulletin 2 (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. In regions subject to seismic requirements, additional bracing of the equipment may be required.

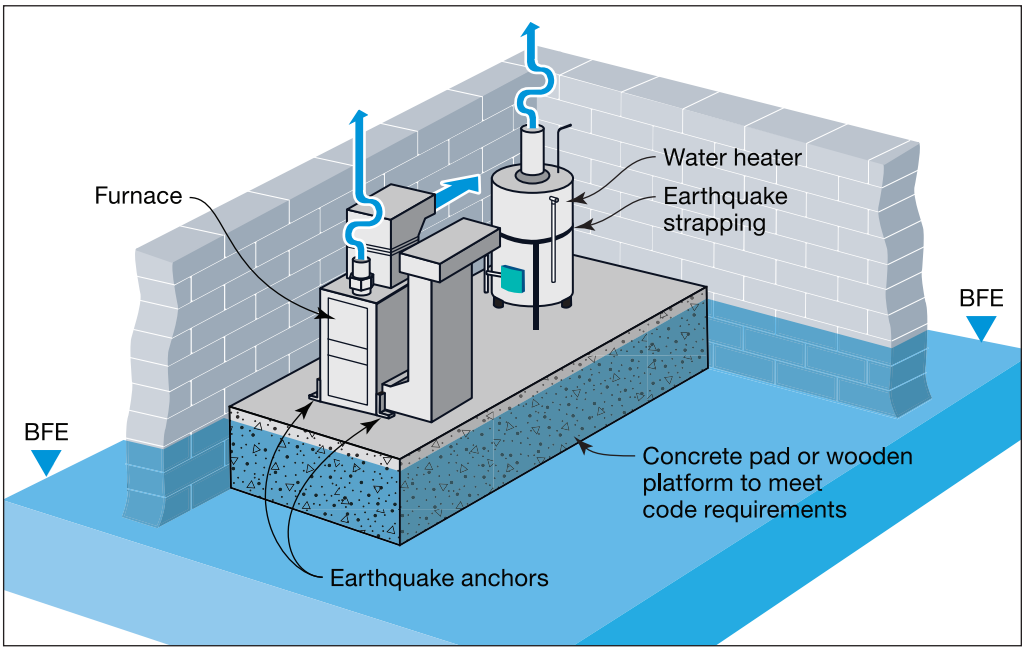

Figure 3: Elevation of mechanical equipment on an elevated platform in an area with the original slab below the BFE

Maintaining Horizontal and Vertical Clearances

When equipment is moved, either to another floor or elevated on a platform, it is important to 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 appliance 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.

Venting Considerations

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

The venting system should be tested to ensure it draws adequate air and backdrafting[2] does not occur. If relocating equipment, homeowners (and their mechanical contractors) must consider the required venting system, as it may affect the final placement of the unit.

Unions, Fittings, and Valves

When it is not feasible to relocate or elevate equipment, it may be possible to replace unions, fittings, or valves to allow faster replacement of equipment when damaged, or to disconnect equipment prior to a flood event and relocate it to a higher floor. While this approach will not bring a non-conforming building into compliance with NFIP requirements, it may reduce potential flood damage to utility systems.

Considerations for Specific Equipment and Systems

Relocating and elevating equipment and systems can be a simple process, like elevating a water heater on a small platform, to 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 or elevate it.

Electrical Panels

Power outages after a flood event are often greatly extended if a house's electrical panel is located below the flood elevation. To reduce this problem, the electrical panel should ideally 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 in order to meet the requirements of the National Electrical Code. Also, when relocating electrical panels, code or local requirements may necessitate replacing significant portions of the house wiring. For additional information on relocating electrical systems, consult the Hurricane Isaac Recovery Advisory No. 2, *Minimizing Damage to Electrical Service Components* (2012).

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 the floodwaters recede. It is easier to replace damaged wiring if it is installed in a conduit.

Mechanical Systems

Mechanical systems include the heating, ventilation, and air conditioning (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. Specifically, the ductwork connected to the furnace and air handler is often the most at risk of flood damage because the furnace is often located in the basement.

In many instances, it may not be possible to elevate mechanical systems above the BFE, but they should be elevated as high as possible. Relocating mechanical equipment may require replacing ductwork and moving electrical supply 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 constructing a platform on posts because posts can obstruct flood-borne debris and are more vulnerable to damage and failure, such as through flood-borne debris impacts and being undermined by scour and erosion.

2 Backdrafting is a sudden explosion of hot gases due to oxygen re-entering an oxygen-starved environment.

Heating systems. ***Boiler systems*** heat water and either force hot water or steam through radiators or baseboards throughout the home and are typically oil- or gas-fired. 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 to reduce flood vulnerability. Although most systems in residential use are hot water systems, the mitigation of a steam boiler is similar. Relocating a boiler heating system to an upper level is ideal, but can present some significant challenges. It may often be more practical to elevate the boiler as high as possible on its current floor. 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 evaluated to make sure it is 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. It may be possible to relocate these systems to upper floors or attic areas. 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, homeowners will need to accommodate the required clearances and venting of the unit.

Water Heaters

Water heaters are powered from an electric coil or are oil or gas-fired. 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, which is not always apparent externally, necessitating replacement of the entire unit.

Electric water heaters. In some buildings, electric water heaters can be relocated to a higher floor or if no space exists on a higher floor, they can be placed in the attic. Relocating the unit will require plumbing and electrical work, as well as a method to drain the tank and prevent water damage from leakage. While relocating a water heater to the attic effectively protects it from flood damage, the heater needs to be equipped with a drain pan and drains 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 on a higher floor is not available, 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. A homeowner may consider using a tankless water heater, which has little storage capacity and heats water instantaneously (see Figure 4). Although more expensive than conventional water heater systems, tankless systems require significantly less space and may present a flood mitigation opportunity due to 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.

Figure 4: Tankless water heater (Atlanta, GA)

Washer/Dryer Units

Many washing machines and clothes dryers are located in basements, where they are vulnerable to flooding. To protect these units from flooding, homeowners can relocate or elevate the units. Relocating the equipment to a higher floor may not be practical if space is limited in the living area. If it is not feasible to elevate these

units very much, even minimal elevation may prevent them 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 or damage to the equipment. Elevating washing machines and clothes dryers may require altering the water and drain piping, electrical connections, and gas connections.

NFIP Requirements for Utility Systems

NFIP requirements apply to buildings located in the SFHA, specifically new construction, buildings undergoing Substantial Improvement or buildings that received Substantial Damage and are undergoing repair. Installing features below the BFE that are not consistent with the allowable uses of building access, parking, and storage renders an enclosed area below the BFE non-compliant. Exceptions to the requirement to locate utility systems above the BFE may be permitted by a floodplain manager or a local code official, provided the element of the system is designed and/or located to prevent water from entering or accumulating within it during flooding conditions. Meeting the exception can be costly or difficult in many cases. Equipment manufacturers should be consulted before approving such an exception to verify that the equipment is designed to prevent damage from, or allow accumulation of, floodwaters.

All building materials below the BFE must be flood damage-resistant. Information on flood damage-resistant materials can be found in FEMA Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (2008). Additional requirements and recommendations apply to structures located in areas mapped as Zone V. Information on below-BFE building elements and free-of-obstruction requirements in Zone V can be found in FEMA Technical Bulletin 5, *Free-of-Obstruction Requirements* (2008).

Requirements for Houses with Substantial Damage

Houses that the local building official or floodplain manager determines to be Substantially Damaged must be brought into compliance with the flood provisions of current building codes, local floodplain ordinances, and NFIP regulations. Requirements include, but are not limited to, elevating utility systems above the flood elevation specified in the codes and regulations. Homeowners attempting to understand how high to properly elevate should consult Hurricane Sandy Recovery Advisory No. 5, *Designing for Flood Levels Above the Base Flood Elevation After Hurricane Sandy*. It is important that homeowners verify with their local building department that they have all permits required to do the project. Relocating or elevating systems in conjunction with other projects may result in the local building department making a determination that the house is being Substantially Improved. Homeowners should consult a local building official to determine whether their local codes and regulations have more restrictive definitions of substantial improvement and substantial damage.

Flood Insurance Implications

Houses built after communities joined the NFIP were required to be elevated to minimize flood damage. These houses should already have elevated utility systems and components. However, if some equipment was not elevated (such as a furnace located in a crawlspace), owners may be paying much higher NFIP flood insurance premiums than necessary. Replacing damaged equipment on elevated platforms not only minimizes future damage, but may result in lowering the cost of flood insurance coverage. Owners should check with insurance agents to find out whether taking this action will affect their flood insurance premiums.

Resources and Useful Links

If a house is subject to flooding, homeowners should consult FEMA flood retrofitting publications to determine if other mitigation options or projects may be appropriate to consider during house renovations. The publications cover a variety of topics, including additional items related to utility system mitigation, such as installing backflow preventers to prevent damage to a system. The FEMA documents referenced can be downloaded from the FEMA Building Science Web site located at http://www.fema.gov/building-science-publications.

The FEMA Region II Web page provides useful information and links for disaster survivors and recovering communities, including available FEMA assistance and recovery initiatives. Please refer to http://www.region2coastal.com.

- FEMA (Federal Emergency Management Agency) P-348. 1999. *Protecting Utilities from Flood Damage*. Washington, DC. Available at http://www.fema.gov/library/viewRecord.do?id=1750.
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- ICC (International Code Council). 2006/2009/2012. *International Building Code*. Country Club Hills, IL. The ICC offers a free viewer that shows the codes at http://www.iccsafe.org/content/pages/freeresources.aspx.
- ICC. 2006/2009/2012. *International Residential Code for One- and Two-Family Dwellings*. Country Club Hills, IL.
- National Electrical Code (2005/2008/2011). National Fire Protection Association (NFPA) 70. Quincy, MA.

For more information, see the FEMA Building Science Frequently Asked Questions Web site at http://www.fema.gov/frequently-asked-questions.

If you have any additional questions on FEMA Building Science Publications, contact the helpline at FEMA-Buildingsciencehelp@fema.dhs.gov or 866-927-2104.

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