Maintenance and Retrofit Options for Key Building Systems

Critical public buildings such as the Emergency Operations Center (EOC), police and fire stations, and hospitals play a vital role in public safety during and immediately after a storm. Their ability to perform is based on a large part of every system in the envelope that protects the building being resilient and properly maintained. The loss of one part of the envelope or other key system means the loss of that building's purpose. Maintenance issues should be identified as early as possible and organized based on cost and importance. The purpose of this fact sheet is to provide options to reduce disaster damage, minimize repair costs, and reduce service losses for key building systems in the Commonwealth of the Northern Mariana Islands (CNMI). This fact sheet describes lower-cost maintenance recommendations and higher-cost wind retrofits to improve building performance in future disasters.

Key Building Systems are the equipment needed to keep buildings serviceable and habitable. Typical key building systems found in the CNMI include:

- heating, ventilation and air conditioning, (HVAC)
- electrical,
- water supply and wastewater systems,
- fuel systems and fuel tanks, and
- communication and life safety systems.

Establishing a Successful Maintenance Program is essential to maintain building system performance. Three key steps for developing and implementing a successful maintenance program are:

1. **Gathering** information is a crucial first step to achieve successful building systems maintenance. The building owner will need to identify existing equipment and gather information about equipment condition and capacity, operating procedures, replacement parts, special tools, suggested service requirements, recommended maintenance schedules, service providers, and warranty information. Most of this information can be found on the equipment tags, in the equipment owner's manual, or on the manufacturer's website. Be sure to update the information when new equipment is added and when existing equipment is replaced.
2. **Training** helps the maintenance staff appreciate the importance of maintenance and how to carry it out. A successful maintenance plan works best when everyone understands how and why it is necessary. Make sure all

relevant team members know when maintenance is due and recognize the signs of damage to key building systems.

3. **Accountability** and audit procedures are needed to ensure compliance with the maintenance plan. Create a list of primary and back-up maintenance staff who follow guidelines developed to help strengthen accountability to help maintain the success of the program. Also, provide updates to equipment maintenance charts each year, or after changes in equipment or procedures.

Maintenance Recommendations and Retrofit Options for Heating, Ventilation, and Air Conditioning

HVAC is a key system to provide a working environment for the occupants of critical buildings. A weakness in installation, maintenance, or operating practices can result in the loss of use of that building. Common types of HVAC units in the CNMI are Rooftop Air Handlers, Package Units, and Split Systems. Rooftop Air Handlers and Package Units are used mainly for schools and larger buildings. Split Systems typically are used in homes and as low-cost replacements for abandoned larger HVAC systems. Not maintaining an individual part or not properly securing equipment to the building or base can result in extended loss of service if repair parts are unavailable.

Unsecured rooftop equipment, such as exhaust fans, fan cowlings, and vent hoods, can blow off during high winds. When this occurs, water can infiltrate the area where they are blown off and the equipment can become wind-borne debris, causing damage to surrounding property. Some examples of HVAC damage observed by the CNMI Mitigation Assessment Team (MAT) who visited the CNMI after Super Typhoon Yutu hit in October 2018 are shown in Figure 1.

Generally, inadequate anchorage, inadequate strength of the equipment itself, and corrosion of fasteners and straps are the sources of failure. Refer to the U.S. Virgin Islands (USVI) RA-2, *Attachment of Rooftop Equipment in High Wind Regions* (2018), for details.

Figure 1. Examples of HVAC damage: blown off mini-split system (left) and corroded wall bracket (right).

A summary of common maintenance recommendations and retrofit options is listed below, with examples shown in Figure 2.

Annual Maintenance Recommendations:

1. Check air handler unit panels regularly and tighten or replace damaged fasteners and seismic bushings to prevent wind damage to panels and to reduce the risk of coil punctures.
2. Regularly change filters, clean coils and follow manufacturer's guidelines for routine maintenance.
3. For mini split systems, ensure base (escutcheon) plates and sealants are checked regularly for damage from insects or sun exposure to prevent leaks at wall penetrations.

4. For rooftop units, anchor the units based on manufacturer's recommendations and ensure brackets and bracings are attached with the correct fasteners to reduce the risk of wind damage from improper anchorage.
5. To prevent water intrusion from abandoned or damaged ducts, remove the ducts and seal the roof penetrations using the same rigid material as the duct, plus a waterproof or weatherproof mastic sealant.
6. Fine debris moved by winds can settle in air conditioner compressors and heat pumps, affecting fin and coil performance. To clean, spray a solution of mild detergent and water onto the evaporator coils, then give it a few minutes to soak in and loosen the dirt and debris. Rinse with a low-pressure water source. Next, wipe away any loosened material with a soft brush or cloth and redo as needed. If the evaporator coils are heavily soiled, consult an HVAC contractor to assess if heavy duty cleaning chemicals and equipment are required.
7. Remove vegetation from around ground-mounted equipment and remove large debris like tree limbs and palm branches that can damage the fins and exterior of the unit as well as internal components.

Retrofit Recommendations:

1. Secure HVAC unit panels with cross bracing to reduce wind damage and avoid coil punctures and other expensive repairs to internal components (see Figure 2). Modifications that can be made on-site include attaching hasps and locking devices like carabiners to secure equipment to the roof or foundation pad. Modification details should be customized and should be similar to the equipment manufacturer's installation instructions. More information is available in FEMA P-424, *Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds* (2010).

Figure 2. Examples of correctly braced HVAC rooftop units and equipment with little or no damage.

2. If the rooftop equipment connection to the concrete base (curb) is inadequate, install high-strength, corrosion-resistant cables or straps tightly over the top of equipment and extend the straps down to the curb or roof structure. Hire a contractor to help with installation.
3. Consider raising ground-mounted equipment on taller platforms if the equipment could be damaged by flooding.

Maintenance Recommendations and Retrofit Options for Electrical Systems

The electrical system is the most important of the critical systems. When this system is not functioning, a building loses the ability operate life safety, HVAC and plumbing equipment. Even using a generator can be difficult or dangerous if components in the electrical system do not function properly, potentially leading to shorting out equipment from surges or fire.

Figure 3. Examples of electrical system damage: corrosion on electrical panel (left) and non-functioning generators (right) see recommendation 3.

Exposed electrical conduit and panels were damaged by wind-borne debris during Yutu. Some of the damaged elements may have needed replacement because of the harsh climate in the CNMI. The damage led to water getting inside and possibly creating more damage to other electrical system components. Conduit connections and rooftop panels should be checked each year. Some examples of electrical system damage observed by the CNMI MAT are shown in Figure 3.

After Yutu, some building owners had emergency temporary generators wired into the building's electrical panel. Direct wiring requires a large effort to correct and can delay providing emergency power to the facility after a storm.

Main Power Systems in many buildings are provided by service drops from the power grid. According to the CNMI Department of the Interior, electric power plants in the CNMI are powered by diesel fuel, with additional energy sourced from solar panels at customer sites for net metering.

Emergency Power Systems are one of three types:

1. (emergency power,
2. legally required standby power, and
3. optional standby power for non-critical use (see National Fire Protection Association (NFPA) 70: National Electrical Code (NEC)).

Emergency and legally required standby systems are used to provide backup power for building systems. This is to make sure that life safety systems and critical equipment, such as emergency lighting, fire alarms, and fire suppression systems, will continue working during power outages. Emergency power systems at the back-up emergency shelters did not have instructions for maintenance and operation upkeep. Portable generators are recommended for the CNMI based on ability to maintain and mobilize for maintenance.

Back-Up Power Systems provide power to equipment that does not threaten life safety or the safety of critical equipment if power is interrupted. Most of the back-up power systems in the CNMI are diesel- and gasoline-powered generators that operate water pumps and non-emergency lighting.

Annual Maintenance Recommendations:

1. Check for loose, uncapped, or exposed electrical conduit and panels. Exposed conduits should be repaired immediately or capped until repairs can be made. Conduit connections and rooftop panels that are exposed to weather should be checked each year for loose conduits and corrosion. Re-secure loose conduit attached to a building. Remove rust, then prime and paint using a corrosion-resistant epoxy coating specified for panel enclosures. Apply dielectric grease to exposed wire to reduce the risk of corrosion. Consult an electrician for detailed assessments.
2. Generators and emergency power systems for schools that are used as recovery shelters should be sized to provide enough power for ventilation, water pumps, and comfort lighting. Emergency power systems serving schools should be maintained and tested annually and should meet the required standards of the National Electrical Code (NFPA 70).
3. Check generators are sized for the potential maximum load. Provide an operation manual in close proximity that includes a maintenance log, location and type of fuel source, and contact information if service is needed (Figure 3). Also, include labels at the breaker showing what breakers should be used while operating the generator to reduce the chance of an overload.
4. Secure service masts attached to buildings. (Figure 4)

Figure 4. Properly secured service mast attached to renovated building.

Retrofit Recommendations:

1. Replace damaged or loose electrical panel enclosures with enclosure types that are more corrosion resistant, such as a National Electrical Manufacturers Association (NEMA) 4/4X watertight enclosure.
2. Provide looped distribution service to supply redundancies in the electrical service to critical facilities, such as hospitals and fire stations.
3. Install surge and lighting protection to prevent power surges that can damage electronics, HVAC equipment, and other appliances.
4. Add generator quick connects (or automatic transfer switches) to critical facilities and public buildings with essential functions to reduce downtime and make it easier to maintain or replace generators with minimum downtime.
5. Upgrade portable generators to meet the post-event load requirements and potential run times. Consider alternating between multiple generators (with quick connect installed to required breakers) to ensure they are able to meet demand.

Maintenance Recommendations and Retrofit Options for Other Critical Building Systems

Examples of damage or poor maintenance to other critical building systems (Water Supply and Wastewater Systems; Fuel Systems and Fuel Tanks; and Communication and Life Safety Systems) observed by the CNMI MAT are shown in Figure 5. Examples of well-maintained systems and equipment from Commonwealth Healthcare Corporation Hospital shown in Figure 6 were properly labeled, painted to reduce corrosion, and included accessible log information located in an easy to assess location.

Figure 5. Examples of critical building system damage: water pump enclosure damage and water reservoir in need of maintenance.

Water Supply and Wastewater Systems in the CNMI are pumped water systems, gravity feed water systems, and rainwater collection systems. Some schools used as emergency shelters had undersized generators to power the pumps to provide sanitary water, causing reduced water availability.

Fuel Systems and Fuel Tanks in the CNMI worked as intended, when properly sized and maintained. Some corrosion was identified at locations with tank reservoirs.

Communications Systems at the CNMI Emergency Operations Center relied on battery back-up in the event of a disaster, due to lack of available technicians to repair emergency power systems.

Life Safety Systems and safety equipment include fire protection systems/sprinklers and emergency alarms. Fire protection and notification devices (horns, bells, strobes) did not appear to be in use at the time of the MAT visit. Battery-powered smoke detectors were in place to provide safety measures until repairs could be made. Buildings should remain unoccupied until permanent repairs are made.

Figure 6. Examples of well-maintained generator fuel tank and pump systems.

Annual Maintenance Recommendations:

1. In many buildings, the fire alarm systems and their devices and wiring were damaged during Yutu. This left many systems inoperable, which had not been repaired at the time the MAT was onsite. To reduce this safety hazard, dedicated or redundant surge protection equipment should be installed on fire alarm panels. Maintenance inspections should include checking electrical conduit for fire alarms.

2. Test Uninterruptible Power Supplies (UPS) serving communication systems to ensure operation during a storm event. Keep a redundant or spare UPS in the event of failure.
3. Check water pumps and piping for corrosion. Inspect water reservoirs for exposed and corroded rebar. Clean areas with corrosion to determine extent of damage and apply a recommended epoxy coating or corrosion-resistant paint to reduce future damage.
4. Inspect water pumps and seals. Check pump flanges for leaks and replace any hoses, seals, or O-rings that have wear or damage. Lubricate components, inspect motors for dirt build-up, and clean when needed in accordance with manufacturer's guidelines.

Retrofit Recommendations:

1. Place water pumps in proper weather enclosures when new pumps are installed or to retrofit existing systems to protect them from increased wear on seals and reduce surface corrosion.
2. Evaluate current power loads needed for UPS. Technology and the power demanded by components can change when upgrading communications systems like the Emergency Alert System and the Commercial Mobile Alert System.
3. Install redundant power supply for critical communications systems. Each of the power supplies will have the ability to run on its own, allowing the equipment to operate with minimum loss of function if one goes down. Additionally, using a UPS as part of the redundant system can also reduce the chance of data loss or equipment failure when transferring from main power to backup power.

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