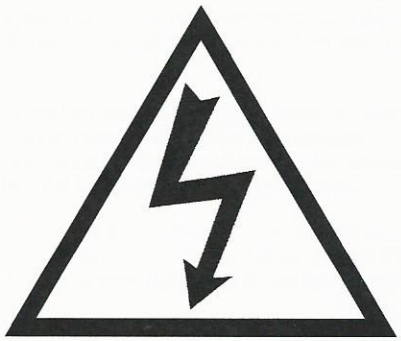
Evaluating Water-Damaged Electrical Equipment



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Evaluating Water-Damaged Electrical Equipment

1 USE OF THIS PUBLICATION

This publication provides information on how to evaluate electrical equipment that has been exposed to water through flooding, fire fighting activities, hurricanes, etc. It is designed for use by suppliers, installers, inspectors and users of electrical products.

Electrical equipment exposed to water can be extremely hazardous if reenergized without performing a proper evaluation and taking necessary actions. Reductions in integrity of electrical equipment due to moisture can affect the ability of the equipment to perform its intended function. Damage to electrical equipment can also result from flood waters contaminated with chemicals, sewage, oil and other debris, which will affect the integrity and performance of the equipment. Ocean water and salt spray can be particularly damaging due to the corrosive and conductive nature of the salt water residue.

Distributors of electrical equipment should not supply any inventory that has been subjected to water damage. This can lead to damaged equipment still being used and creating a hazard to individuals or property.

2 CONTACT THE MANUFACTURER

Working knowledge of electrical systems and of the equipment in question is required to evaluate damage due to contact with water. The original manufacturer of the equipment should be contacted if any questions arise or specific recommendations are needed. In many cases, replacement will be necessary.

After consultation with the manufacturer, some larger types of electrical equipment may be reconditioned by properly trained personnel. The potential to recondition the equipment may vary with the nature of the electrical function, the degree of flooding, the age of the equipment, and the length of time the equipment was exposed to water.

Attempts to recondition equipment without consulting the manufacturer can result in additional hazards due to the use of improper cleaning agents, which can further damage the equipment (see *National Electrical Code®* Section 110.11 Informational Note No.2) or due to improper reconditioning techniques.

NEMA member companies are committed to safety. For specific contacts within these manufacturing firms, call or write:

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3 ELECTRICAL EQUIPMENT REPLACEMENT/RECONDITIONING REQUIREMENTS

The table shown below provides the requirements and recommendations associated with various categories of electrical equipment that have been subjected to water damage. Where it is shown that the equipment "may be reconditioned" it is critical that the manufacturer of the equipment be contacted for specific guidance.

Equipment	Replace Equipment	May be Reconditioned (Contact the manufacturer.)	Additional Standards Reference (if available)
ELECTRICAL DISTRIBUTION EQUIPMENT (refer to 4.1)			
Molded case circuit breakers	X		
Low voltage fuses	X		
Switches	X		NEMA KS 3-2010, *Guidelines for Inspection and Preventive Maintenance of Switches Used in Commercial and Industrial Applications*
Busway (mylar wrapped bars)	X		NEMA BU 1.1-2000, *General Instructions for Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less*, para 3.4.4, 9.2.4.2
Busway (powder coated bars)		X	
Panelboards		X	NEMA PB 1.1-2002, *General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less*, para. 10.3, 10.8.3, 10.8.4
Switchboards		X	NEMA PB 2.1-2002, *General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less*, para. 11.3.1.3, 11.10
MOTOR CONTROL EQUIPMENT (refer to 4.2)			
Adjustable speed drives		X	
Components containing semiconductors and transistors	X		
Electronically controlled and solid state contactors and starters	X		
Overload relays	X		
Manual and magnetic controllers		X	
Motor control centers (see 4.2.2)		X	

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Equipment	Replace Equipment	May be Reconditioned (Contact the manufacturer.)	Additional Standards Reference (if available)
POWER EQUIPMENT (refer to 4.3)			
Electronic trip units of LV power circuit breakers	X		
High-voltage circuit breakers (AC)		X	
Low voltage power circuit breakers		X	
Protective relays, meters, and current transformers (see section 4.11 for devices that contain electronic components)		X	
Low voltage switchgear		X	
Medium voltage switchgear		X	
TRANSFORMERS (refer to 4.4)			
All dry-type transformers regardless of kVA ratings	X		
All dry type control circuit transformers	X		
Liquid-filled transformers	X (Analysis of the insulating medium is required for evaluation of this equipment.)		
Cast-resin transformers	X		
CONDUIT, TUBING, FITTINGS, OUTLET BOXES AND JUNCTION BOXES (refer to 4.5)			
Fittings	X		NEMA FB 1-2007(R2010), *Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing (EMT) and Cable*
Outlet and Junction Boxes	X		NEMA OS 1-2008 (R2010), *Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports* NEMA OS 2-2008, *Nonmettalic Outlet Boxes, Device Boxes, Covers and Box Supports*
Conduit and Tubing		X	

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Equipment	Replace Equipment	May be Reconditioned (Contact the manufacturer.)	Additional Standards Reference (if available)
WIRE, CABLE AND FLEXIBLE CORDS (refer to 4.6)			
Wire or cable listed for dry locations (such as NM-B)	X		
Wire or cable that is suitable for wet locations (Provided the ends of the wire or cable have not been exposed to water and the wire is not damaged.)		X	
AFCIs, GFCIs, SURGE PROTECTIVE DEVICES AND WIRING DEVICES (refer to 4.7)			
Arc Fault Circuit Interrupters (AFCI) and Ground Fault Circuit Interrupters (GFCI)	X		
Surge Protective Devices (transient voltage surge suppressors, surge arresters, lightning arresters)	X		
Wiring Devices (switches, receptacles, dimmers, etc.)	X		
OTHER DEVICES			
Cable Tray (refer to 4.8)		X (Replace damaged labels.)	
`Fire Pump Controllers		X	NEMA ICS 15-2011, *Instructions for the Handling, Installation, Operation, and Maintenance of Electric Fire Pump Controllers Rated Not More Than 600V*
Luminaires (lighting fixtures), ballasts and LED Drivers (refer to 4.9)	X		
Motors (refer to 4.10)		X	ANSI/IEEE 43-2000, A2 and A3
Signaling, Protection and Communications systems (refer to 4.11)	X		

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4 THE HAZARDS ASSOCIATED WITH WATER-DAMAGED ELECTRICAL EQUIPMENT

4.1 Electrical Distribution Equipment

Electrical distribution equipment usually involves switches and low-voltage protective components such as molded case circuit breakers and fuses within assemblies such as enclosures, panelboards and switchboards. These assemblies can be connected to electrical distribution systems using various wiring methods.

The protective components are critical to the safe operation of distribution circuits. Their ability to protect these circuits is adversely affected by exposure to water and to the minerals, contaminants, and particles, which may be present in the water. In molded case circuit breakers and switches, such exposure can affect the overall operation of the mechanism through corrosion, through the presence of foreign particles, and through loss of lubrication. The condition of the contacts can be affected and the dielectric insulation capabilities of internal materials can be reduced. Further, some molded case circuit breakers are equipped with electronic trip units and the functioning of these trip units can be impaired. Water may affect the filler material of fuses and will degrade the insulation and interruption capabilities.

Distribution assemblies contain protective components together with the necessary support structures, buswork, wiring, electromechanical or electronic relays and meters. Exposure to water can cause corrosion and insulation damage to all of these areas. In the case of exposure of distribution assemblies to water, contact the manufacturer before further action is taken.

4.2 Motor Control Equipment

Motor circuits include motor control devices such as motor starters and contactors, together with overcurrent protection components such as overload relays, circuit breakers, and fuses are often assembled into motor control panels and motor control centers as well as individual enclosures. Motor control centers contain both control and protective components together with support structures, buswork and wiring.

The protective components are critical to the safe operation of motor circuits and their ability to protect these circuits is adversely affected by exposure to water, and to the minerals, contaminants, and particles, which may be present in the water. For molded case circuit breakers, such exposure can affect the overall operation of the mechanism through corrosion, through the presence of foreign particles, and through loss of lubrication. The condition of the contacts can be affected and the dielectric insulation capabilities of internal materials can be reduced. Further, some molded case circuit breakers are equipped with electronic trip units, and the functioning of these trip units can be impaired. Water may affect the filler material of fuses and will degrade the insulation and interruption capabilities.

Corrosion, loss of lubrication and insulation quality can also be expected in contactors and starters. Solid-state motor controllers, adjustable speed drives and those electromechanical contactors or starters with integral electronic circuitry will be more severely affected by water.

4.2.1 Adjustable Speed Drives

Adjustable Speed Drives generally contain electronic components. See section 4.11 for information on equipment with electronic components. For other components of an adjustable speed drive, the ability to refurbish those components will depend on the type of component involved and the extent of the damage. The manufacturer of the drive must be consulted prior to any attempt to refurbish the equipment.

4.2.2 Motor Control Centers

Motor control centers contain many different components including fuses, circuit breakers, controllers, overload relays, adjustable speed drives and components such as buswork, insulators and enclosures.

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Many of these components are covered in other parts of this document and should be referenced for additional information on those components.

For the buswork and structural assembly, exposure to water can cause corrosion and insulation damage. For these assemblies contact the manufacturer before further action is taken.

4.3 Power Equipment

Power equipment involves low voltage or medium voltage protective devices within an overall switchgear assembly. The assembly may also contain cabling, buswork with appropriate insulators, current transformers, electromechanical or electronic relays, and metering. Reliable operation of the protective devices is vital to system safety. These devices can be adversely affected by water. In the case of low voltage power circuit breakers and medium voltage circuit breakers and switches, the operation of the mechanism can be impaired by corrosion, by the presence of particles such as silt, and by the removal of lubricants. The dielectric properties of insulation materials and insulators will degrade and, for air circuit breakers, the condition of the contacts can be affected. Further, low voltage power circuit breakers usually incorporate electronic trip units; the functioning of these units will be impaired. Similarly, the functionality of electronic protective relays and meters can be impaired. See section 4.11 for additional information on electronic components.

Water may affect the filler material of fuses and will degrade the insulation and interruption capabilities.

Low voltage power circuit breakers and medium voltage breakers are designed to be maintainable with the possibility of replacing contacts in air circuit breakers. Therefore, it maybe possible to reuse such circuit breakers provided the refurbishing is performed in close consultation with the manufacturer. This includes cleaning and drying techniques, lubrication advice, and thorough testing prior to the reapplication of power. However, discard and replace the electronic trip units of low voltage power circuit breakers, and electronic protective relays and meters in any power equipment.

Replace fusible units of fused equipment. The remainder of the apparatus may be suitable for refurbishing in close consultation with the manufacturer.

In all cases, great attention must be paid to the thorough cleaning, drying, and testing of insulators and insulation material.

The power equipment can be expected to contain additional electronic units such as solid state relays. These units can also be vital to the correct functioning of the protective device, and great care is needed in the cleaning and testing of such units. A first recommendation is to return the devices to the manufacturer. If this is not possible, the manufacturer should be consulted on the correct selection of cleaning agents that remove impurities without damaging the conformal coating. The manufacturer shall also be contacted for the specific testing required of sophisticated electronic equipment containing, for example, microprocessors.

The overall power equipment assembly (switchgear) may be able to be reconditioned provided careful steps are taken in the cleaning, drying and testing of the equipment prior to applying power. This requires input and advice from the manufacturer. An area of particular concern is the maintenance of the dielectric properties of insulation. In the field application of medium voltage equipment, standoff insulators are subjected to a wide variety of high voltage surges. Such insulators may need replacement.

4.4 Transformers

Exposure of transformers to water can cause corrosion and insulation damage to the transformer core and winding. The ability of the transformer to perform its intended function in a safe manner can also be impaired by debris and chemicals, which may be deposited inside the transformer during a flood. Water and contaminates will also damage the transformer fluids.

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4.5

4.5.1 Outlet Boxes and Fittings

Outlet boxes and fittings, whether metallic or nonmetallic, for use in indoor dry locations have not been evaluated for effects of exposure to conditions described in "Use of this Publication". The presence of known or unknown corrosive agents in flood water in particular can affect the physical properties of nonmetallic materials and the required corrosion protection for electrical equipment according to NEC Section 300.6. Therefore, replacement of outlet boxes and fittings in accordance with original installation requirements is recommended.

4.5.2 Conduit and Tubing

In the case of flooding, fire-fighting activities or other instances of unusual water exposure, conduit and tubing must be carefully inspected to determine if the mechanical and electrical integrity of the conduit/tubing system has been compromised. Flood waters, in particular, may be contaminated with oil, chemicals, sewage and other debris that could enter the conduit/tubing and prevent a clear path for the replacement of conductors or cables. As part of the inspection process, assure that the interior of the conduit/tubing is clear. In addition, contaminants may also affect the physical properties of metallic and nonmetallic materials and the corrosion protection for electrical equipment as required in NEC Section 300.6. Since every situation has unique circumstances the services of an experienced evaluator should be used. The manufacturer can also be consulted for additional assistance.

4.6 Wire, Cable and Flexible Cords

When any wire or cable product is exposed to water, any metallic component (such as the conductor, metallic shield, or armor) is subject to corrosion that can damage the component itself and/or cause termination failures. If water remains in medium voltage cable, it could accelerate insulation deterioration, causing premature failure. Wire and cable listed for only dry locations may become a shock hazard when energized after being exposed to water.

Any recommendations for reconditioning wire and cable in Section 1.0 are based on the assumption that the water contains no high concentrations of chemicals, oils, etc. If it is suspected that the water has unusual contaminants, such as may be found in some floodwater, the manufacturer should be consulted before any decision is made to continue using any wire or cable products.

4.7 AFCIs, Wiring Devices, Ground Fault Circuit Interrupters (GFCI) and Surge Protective Devices

Sediments and contaminants contained in water may migrate into the internal components of installed electrical products and remain there even after the products have been dried or washed by the user. These may adversely affect the performance of those products without being readily apparent to the user community. Also, electrical products, such as AFCIs, GFCIs and surge protective devices, contain electronic circuitry and other components, which can be adversely affected by water resulting in the device becoming non-functional or a hazard to the user. Air drying and washing of water damaged products of this type should not be attempted.

4.8 Cable Tray

Carefully inspect the cable tray system to determine if its mechanical and/or electrical integrity has been compromised. Repair or replace any damaged portions per original installation requirements. Remove all debris from the cable tray. If any labels warning against the use of the cable tray as a walkway have been damaged, obtain new labels from the manufacturer and apply as required.

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4.9 Luminaires (Lighting Fixtures), Ballasts and LED Drivers

Fluorescent, high-intensity discharge, incandescent and LED luminaires are not intended for submersion in water except for those that are listed as submersible luminaires. Flooded luminaires and associated equipment may be damaged by corrosive materials, sediment, or other debris in the water. Corrosion of metallic parts and contamination of internal circuitry may prevent the equipment from operating properly.

4.10 Motors

Motors that have been flooded by water may be subjected to damage by debris or pollutants. This may result in damage to insulation, switches, contacts of switches, capacitors and overload protectors, corrosion of metallic parts, and contamination of the lubricating means and should be evaluated by qualified personnel.

4.11 Electronic Products, Including Signaling, Protection, Communication Systems and Industrial Controls

Equipment used in signaling, protection and communication systems generally contain electronic components, and the exposure of such equipment to water or corrosives can adversely affect the reliability of those systems. Contamination by pollutants or debris in flood waters may cause corrosion of components of the system, shorting or alteration of printed circuits, or alteration of circuit characteristics. Since some of these types of installations are classified as life safety systems, it is important that the reliability of those systems be maintained.

Where such systems are damaged by water, replace components of these systems or return the equipment to the manufacturer for appropriate cleaning, recalibration, and testing. Manufacturers of these systems should be contacted for information on specific equipment.

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