Chapter 32 Electrical Disaster Recovery

32.1 Introduction. When electrical systems are faced with a natural or man-made disaster, a very specific and detailed sequence of events should occur to return the electrical system to operation in a safe and expeditious manner. Actions can also be taken to reduce the damage to the system to shorten the system recovery time frame. After a disaster event, it is especially critical to analyze and repair the electrical power system in a safe and logical sequence. This chapter describes the recovery steps for an electrical power system and related equipment that should be followed before and after an electrical disaster event occurs.

32.2 Catastrophic Event Categories. The events surrounding a disaster can be detailed into specific event phases.

32.2.1 The Initial Event. Disaster recovery efforts can be a result of both natural and man-made disasters. Disaster scenarios including, but not limited to, the following inflict damage of varying degrees to facilities:

(1) Fire: soot, material and equipment damage, water damage, structural damage
(2) Flooding: water damage, structural damage
(3) Hurricane: water damage, structural damage, utility infrastructure damage
(4) Tornado: water damage, structural damage, utility infrastructure damage
(5) Earthquake: structural damage, utility infrastructure damage

32.2.2 Securing the Facility to Limit Damage. If possible, a facility should be secured prior to the disaster event to limit electrical and mechanical damage to equipment and systems. Electrical and mechanical systems should be shut down and secured, and critical components should be removed or preserved. Examples of tasks to limit damage are as follows:

(1) Remove critical equipment from their base and raise them above the flood line or remove them from the flood site.
(2) De-energize power to prevent electrical short circuit and arcing damage.
(3) Secure storage tanks and other large devices that can float away.
(4) Sandbag the fronts of electrical equipment rooms to limit water and debris entry.
(5) Remove critical computer and electronic equipment from the site.
(6) Remove all electrical equipment, drawings, manuals, and supplies stored at ground level.

32.2.3 Mobilization of Recovery Personnel. During large-scale disaster events, one of the biggest challenges for a commercial or industrial facility is providing enough qualified contractors and disaster recovery specialists to perform required remediation to the facility. Prior to a disaster event occurring, a preplan should be developed for the mobilization of recovery personnel. Consideration should also be given to personnel needs during disaster recovery, including a plan to address physical needs and basic provisions such as transportation, food, shelter, and hygiene.

32.2.3.1 In-House Personnel. Before a disaster event occurs, personnel responsible for the disaster recovery operations and facility repair should be designated and have possession of any applicable action plans. Depending on the magnitude of the event, the recovery effort can be done solely with in-house personnel or with the assistance of professional restoration companies.

32.2.3.2 Outsourced (Contract) Personnel. Prior to a disaster event, facilities should consider establishing master service agreements (MSAs) with multiple qualified vendors who specialize in electrical disaster recovery services. Doing so prevents confusion and delays in the recovery efforts. Decide who will perform the cleanup (debris removal and electrical equipment restoration) and supply support equipment (e.g., flood pumps, heavy equipment and operators, emergency power equipment, and temporary electrical services). Qualified repair facilities should be identified prior to a disaster recovery event.

32.2.3.3 Notification to Insurance Carrier. As soon as feasible the site insurance carrier's claims representative should be notified of the event.

32.2.4 Developing a Safety Plan. A site-specific safety plan should be developed before a disaster occurs. When performing recovery of electrical equipment, safety, environmental, and health are paramount. Lockout/tagout, test before touch, and the application of safety grounds are typically covered in site electrical safety plans. While these are key safety aspects of placing equipment into an electrically safe condition, there are

other items of safety that need to be addressed and integrated into the safety plan, such as the following:

(1) Air quality
(2) Structural issues
(3) Chemical and biological hazard spill exposure
(4) Site-specific hazards
(5) Site-specific PPE requirements

32.2.5 Temporary and Emergency Power Generation. When disaster events occur, often times there is a loss of normal utility power. This creates a unique safety and logistical challenge to provide the required electrical power in a facility for critical systems and lighting. The temporary power portion of the project should be managed to reduce the risk of shock and arc-flash hazards. There should be dedicated personnel responsible for temporary power, and they should develop all written standards and procedures to be followed. Typical emergency power procedures should identify elements such as the following:

(1) Backfeeding of equipment
(2) Individual motor starters for pumps
(3) Temporary signage and barricades
(4) Site generator location maps.
(5) Fueling schedules
(6) Written form for the addition of electrical power
(7) Access and exhaust flow

32.2.6 Initial Damage Assessment. One of the first tasks in assessing equipment and system damage to electrical equipment involved in a disaster event is to gather all pertinent drawings and documentation available and perform a walkthrough and initial assessment of the entire electrical infrastructure.

32.2.6.1 Drawings, Schematics, Equipment Documentation. In some instances drawings and documentation are not available due to destruction from the disaster event. All equipment instruction books, operation and maintenance (O&M) manuals, and documentation should be identified and centrally located.

32.2.6.2 Priority Assessment. Equipment repair priorities should be assessed with a focus on the highest priority equipment. Examples of typical equipment categories are as follows:

(1) Category 1: medium-voltage equipment including distribution transformers
(2) Category 2: low-voltage distribution equipment
(3) Category 3: electric motors
(4) Category 4: balance of the plant

32.2.7 Documentation. All electrical components or equipment should be properly documented prior to removal to ensure the equipment is reinstalled properly as found. The documentation process includes the following:

(1) Tag each piece of equipment.
(2) Label all control and power wires.
(3) Take a digital picture of each piece of equipment.
(4) Sketch an accurate diagram of each piece of equipment on the electrical equipment drawing sheet.
(5) Fill out the electrical equipment tracking form.
(6) Save all pictures on a local database.
(7) File the electrical equipment drawing sheet.
(8) Create a master electrical equipment tracking document.
(9) Ship documents of all electrical equipment.

32.2.7.1 Service Shop Activities. If equipment is to be removed from the affected facility for repair at an offsite service center, the equipment should be tagged, identified, and tracked and the status updated on a master equipment repair database.

32.2.7.2 Equipment Tag. Information on each tag should include a unique sequence number, plant identification number, plant description, date, power center, or room number. The tag should be filled out with a medium point permanent marker so the information is legible. The tag should be attached to the equipment with a secure plastic wire tie.

32.2.7.3 Labeling of Wires. All control wires should be labeled with wire numbers and the power wires with colored phasing tape. Make sure that each side of the termination, both wire and connected device, is identified. This will ensure the wiring will be re-connected as it was originally installed.

32.2.7.4 Photographs of Equipment. After the equipment is tagged and the wires are labeled, a minimum of three photographs should be taken of each piece of equipment. The first photo should include the equipment tag in the picture, making sure the tag is legible and the picture is clear. The second photo is an overall view for the sole purpose of wire clarification/documentation during the reinstallation process and should include all wiring associated with the applicable device. The third photograph should be of the equipment nameplate. Additional photographs should be taken as deemed appropriate.

32.2.7.5 Field Sketch. An accurate field sketch of the electrical equipment should be generated. The sketch should be recorded on a site-specific electrical equipment drawing sheet template. This drawing sheet should include the job name, job number, power center, sequence number, plant equipment number, plant description, technician name, date, and enough room to sketch the piece of equipment.

32.2.7.6 Equipment Tracking Sheet. After a sketch is made of the piece of equipment, the equipment should be added to an electrical equipment tracking sheet. The electrical equipment tracking sheet should be customized and detailed. The tracking sheet should include general information such as overall condition, item number, sequence number, priority, area of the plant, power center or room number, transformer, substation, cell position, equipment type, circuit identification, plant identification number, manufacturer, percent water level, model number, frame size, and voltage. Field tracking information should also include date documented, date pulled, date shipped, date returned, date installed, and any dates that quality assurance procedures were performed.

32.2.7.7 Repair or Replace. During the documentation process, initial decisions should be made pertaining to each piece of equipment that is damaged. Seeking the services of qualified equipment assessment personnel, whether manufacturer representatives or subject matter experts, is important in the decision making process.

32.2.7.7.1 Repair or Replace Decisions. Many factors can affect the repair/replace decision. Some of the likely decisions are as follows:

(1) Can the equipment be repaired or does the equipment need to be replaced?

(2) Can the repairs take place on site or does the equipment need to be sent to a repair facility?

32.2.7.7.2 Repair or Replace Factors. Some of the factors that can affect the repair or replace decision are as follows:

(1) Is the equipment currently manufactured?
(2) Are there long lead times to replace with new?
(3) Will equipment performance be compromised if repaired?
(4) What is the age of the equipment?
(5) What is the reliability requirement?
(6) Can it be effectively repaired?
(7) Is the manufacturer still in business?
(8) Is the repair contractor qualified for the task?
(9) Will the authority having jurisdiction allow repair or replacement?
(10) What is the financial impact?
(11) What is the total outage time required?

32.2.8 Industry Standards and Guidelines. Industry standards and guidelines should be referred to for information. Information is available from the following:

(1) Electrical Apparatus Service Association (EASA), ANSI/EASA AR100, *Recommended Practice for the Repair of Rotating Electrical Apparatus*
(2) Federal Emergency Management Agency (FEMA), FEMA P-348, *Protecting Building Utilities From Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems*
(3) Institute of Electrical and Electronic Engineers (IEEE), IEEE 3007.2, *Recommended Practice for the Maintenance of Industrial and Commercial Power Systems*
(4) National Electrical Manufacturers Association (NEMA) NEMA, *Evaluating Water-Damaged Electrical Equipment*
(5) InterNational Electrical Testing Association (NETA) ANSI/NETA ATS, *Standard for Acceptance Testing Specification*
(6) ANSI/NETA MTS, *Standard for Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems*
(7) National Fire Protection Association (NFPA), *NFPA 70* and *NFPA 70E*
(8) PowerTest Annual Technical Conference, 2009, *Flood Repair of Electrical Equipment; March 12, 2009, Pat Beisert, Shermco Industries*
(9) National Electrical Manufacturers Association (NEMA), *Evaluating Fire- and Heat-Damaged Electrical Equipment*

32.2.9 Medium-Voltage Equipment. Medium-voltage equipment typically serves as the backbone to the electrical power system and should be the primary focus of the initial recovery activities.

32.2.10 Low-Voltage Distribution Equipment. Affected components of low-voltage equipment should be removed to facilitate cleaning and drying of the structures. During the removal of the equipment, care should be taken to keep all wiring for each component well marked and together.

32.2.11 Electric Motors. When a disaster event involves water, electric motor repair is a major component of a flood recovery project. The documentation process is very similar to other electrical equipment but there are additional items that should be documented. The documentation process should include the following:

(1) Record nameplate data and location of the motor.
(2) Tag the motor base and the motor with a unique sequence number.
(3) Mark and record electrical connections.
(4) Record coupling information and condition of coupling.
(5) Mark and record shim information.
(6) Collect all mounting hardware, couplings, and shims and store in its own labeled container. This equipment stays on site and should be stored in a central location.

32.2.12 Power and Control Wiring. Power and control wiring should be tested to determine serviceability. *(See 11.21, Cables.)*

32.2.13 Balance of Plant Electrical Repair. The balance of plant consists of all equipment other than medium-voltage equipment, low-voltage distribution equipment, and motors. These devices are typically repaired by replacement.

32.2.14 Re-energization of the Facility. Initial re-energization to utility power of a facility damaged by a disaster event should be carefully planned and methodically implemented. To reduce the possibility of accidental energization of equipment it might be prudent to forego any utility energization until all affected equipment has been repaired or replaced.

32.2.15 System Commissioning During. Re-energization of the facility, the equipment operation, and performance should be verified. *[See Chapter 31, EPM from Commissioning (Acceptance Testing) Through Maintenance and Figure H.35 in Annex H.]* A period of monitoring should be established to verify and document proper operation has been restored.

32.2.16 Project Summary. After a disaster recovery event there is information gathered that should be available for future reference. The final project report should contain this data and should include information such as the following:

(1) As-found conditions of the electrical infrastructure
(2) Listing of equipment repaired or replaced
(3) Test results of all equipment tested
(4) Assessment of individual equipment condition
(5) Long-term equipment replacement plan