“A critical facility that is fully compliant with the minimum building code requirements may not be able to operate as needed or provide the expected services when power is lost.”
FEMA Mitigation Assessment Teams (MATs)

Conduct post-event forensic engineering

• Identify failures (and hopefully some successes)

• Goals:
  • Reduce future damages by providing guidance to communities, states and other organizations
  • Improve performance through:
    • Improved codes and standards
    • Improved designs
    • Improved methods and materials
MAT Observations & Recommendations have contributed to:

- Guidance documents
  - Building Science Publications
- Building Codes and Standard Revisions
  - IBC, IRC, ASCE 24, etc.
- Outreach
NYU Langone

- 1,069 bed teaching hospital
- Located along FDR Drive/Harlem River
- In Flood Zone AE-10
- Portions below grade

Sunday October 28th

- News predicted a 10% to 15% chance of 4 to 10 ft. of surge (a 5% chance of 16 ft.)
- Pre-evacuated 250 patients
- Moved 162 patients to safer areas
- Installed shields and sandbags
- Positioned staff to handle seepage

- Felt “well prepared”
FEMA P-1019 Background
Sandy NY (2012)

Monday, October 29

- 6:30 PM floodwaters breached walls along FDR Drive and entered Smilow Research Center
- 7:30 PM Normal Power Lost (Con Ed 14th St Substation?)
- “Catastrophic Breaches” in basement
  - North to South and East to West
  - Flowed rapidly through utility tunnels
  - “Ankle to waist deep in minutes”
  - Totally filled below grade levels; 2 feet (+/-) water on ground floor
FEMA P-1019 Background Sandy NY (2012)

• Could not pump fuel from the 25,000 gal main fuel tank to 300 gal day tanks
• Generators ran out of fuel and shut down in about 3 hours
• After generators shut down:
  • 8:00 PM: ordered evacuation (during height of storm)
  • 322 patients evacuated; 44 were critically ill; 3 too ill to move
  • Lost elevators; stairwells dark
  • Patients were carried down dark stairwells lit with flashlights
  • Evacuation took 13 hours — no deaths
For most buildings, codes do not address:

- The relative vulnerability of the nation’s electrical transmission & distribution system “The Grid”
- Continued operations during loss of normal power

Some guidance exists:

- FEMA 543 (Critical Facilities) and FEMA 577 (Hospitals)
- Florida Dept. of Community Affairs Shelter Guidance

Most current guidance focuses on the integrity of the structure and envelope, not on the systems that must operate for the facility to function

Little guidance existed on “how” to provide emergency power and “what” to power
FEMA P-1019 Need for Guidance
Natural Hazards

High Winds and Winter Storms
FEMA P-1019 Need for Guidance
Natural Hazards

Flooding

NOTE: Red lines indicate flood depth
Earthquakes
Emergency Power Requirements of the IBC

- “Fire-centric”
- Based on premise that people are safer outside than in
- Only enough power for occupants to safely leave a building *
- Do not address needs of facilities that must remain operational during prolonged power outages
Typical Loads Requiring Emergency Power

Life safety loads

- exit and emergency lights (egress paths)
- fire alarms
- stairwell pressurizing fans
- power operated doors and locks

Other loads

- elevators in high rise buildings
- fans for air supported structures

Emergency Power Duration

- 90 minutes for most occupancies
- Can be met using stored energy devices
“Needed Needs” vs “Wanted Needs”

Equipment that must operate allow a critical facility to function.

Equipment that needs to operate depends on:
  • The function of the critical facility
  • The duration that the critical facility needs to operate

• Mechanical cooling
• Fire pumps
FEMA P-1019 Emergency Power Required by Function

• Lighting
• Heating & ventilation equip
• Critical pumps
  • Sump pumps
  • Circulating pumps
  • Sewer lift pumps
• Telephone and IT
• Food prep & preservation
• Air conditioning
Emergency/Standby Generators

- Engines & Generators
- Controls
  - Start/stop
  - load shedding
  - synchronizing
- Fuel supplies and systems
  - Adequate capacity
  - Reliable (not interrupted)
  - Quality (fuel degradation)
Emergency Power Distribution Systems

- Similar to Normal Power System - Includes
  - Switchboards, conduit, wiring, protective devices
- Can be supplied from either Normal Power or Emergency/Standby Power (but not simultaneously)
  - ATS (required for emergency systems)
  - MTS (may be allowed for standby or optional systems)
• Normal power source
• Emergency power source (diesel generator protected from elements)
• ATS (automatic) or MTS (manual) transfer switch connects critical distribution to either normal or emergency power (but not both)
• Electrical equipment (feeders, panels, circuits) to deliver power to critical loads
Portable Generators

- Can NOT be used for code required emergency power
- Should NOT be used where power is needed before generator can be delivered and connected
  - Have contracts in place before the event
  - Consider alternate delivery routes
- Can be a cost effective solution for many facilities
Portable Generators (cont.)

- Provisions recommended for:
  - Quick and safe connections
  - With no potential for back feeding
“If proper considerations are made, what may be extremely difficult to achieve in existing construction can readily be achieved with a new facility.”

“The keys to a successful design are the following:

(1) getting all design professionals and the building owners and operators to take a holistic approach to the design process; and

(2) having the design team work closely with the owner or operator of the facility to identify all critical operations that must remain functional when utility power is lost.”
Caution with term “Emergency Power”

Life Safety Code (NFPA 101)

National Electrical Code - Chapter 7

- Emergency systems (Art 700)
  - Life safety loads
- Legally required standby systems (Art 701)
  - Smoke control, elevators, etc.

Most of the power needs for functionality are not code required and governed by:

- Optional standby systems (Art 702)
- Article 702 offers more flexibility Art 700 & 701
Holistic Approach to Systems

• “What” equipment need emergency power
  • System interdependencies must be identified

• “How” to provide power to that equipment
  • All components must be designed and constructed so they are not vulnerable to hazards
  • Entire system must resist multiple hazards (flood, high winds, earthquakes, etc.)
Multi-Hazard Approach

- High Winds
- Earthquakes
- Floods
Wind

• FEMA P-1019
  • IBC *International Building Code*
  • ASCE 7 *Minimum Design Loads for Buildings and Other Structures*
  • ICC 500 *ICC/NSSA Standard for the Design and Construction of Storm Shelters*
  • Design for partially enclosed building where louvers exist
• FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds*
  • Provide secondary roof barrier
  • Provide wind borne debris impact protection
  • Mitigate lay-down hazards
Earthquakes

- IBC *International Building Code*
- ASCE 7 *Minimum Design Loads for Buildings and Other Structures*
  - All critical equipment
  - All interconnecting piping and wiring
  - Recommends structural engineering involvement with MEP support and anchorage
- FEMA E-74, *Reducing the Risks of Nonstructural Earthquake Damage – A Practical Guide*
FEMA P-1019 Designing Emergency Power Systems in New Facilities

Flood

• Design Critical Facilities per ASCE 24-14

• Elevate or protect to:
  • Locally adopted Design Flood Elevation (DFE)
  • Cat III
    • Base Flood Elevation (BFE) plus 2 ft.
  • Cat IV
    • Higher of Base Flood Elevation (BFE) plus 2 ft.
    • 500-year flood elevation (0.2% chance of being met or exceeded annually)
  • Sandy MAT Recommended additional freeboard for critical systems

• Avoid Dry-Floodproofing

• FEMA P-348 *Protecting Building Utilities From Flood Damage*
Providing standby power is voluntary rather than mandatory:
- If voluntary – there will be a lot of leeway
- If mandatory – there will be Code implications

Will most likely require some electrical reconfiguration:
- Installation of transfer switches
- Separation of critical and non-critical loads

Consider portable sources:
- Water and waste water pumping stations
- Gas service stations
- Others

Recognize limits on physical protection in existing facilities.
Potential Code Implications

• The NEC defines emergency power and has strict limits on providing that for code required emergency power

• Ramifications from Change of use/occupancy

Phased Approaches

• Make improvements during the replacement of obsolete equipment

• Identify desired outcomes early on in process
Appendix B: Redundancy

Example of N+1 for normal power systems

- Double ended service with tie breaker
- Either service can supply the entire facility
- Significantly reduces outage durations experienced by the loss of one service normal loads
Generator Sizing

- Predicting operating loads (demand and diversity factors)
- Starting largest motor while base loaded
  - Locked rotor code letters (difficulty to start)
  - VFDs and reduced voltage starters
- Voltage dip, Frequency dip, stalling
- Cold stacking, inefficient operations
Questions
DATA Center NYC (Sandy 2012)

- Located on Hudson River
- Built 1914

Critical Equipment

- Electric Service, ATSs on 1st floor
- Boilers on top floor
- Fuel tanks in basement (40,000 gallon total)
  - Serve generators on upper floors
  - Tanks and pumps in floodproofed area
- Six sump pumps in basement
DATA Center NYC (Sandy 2012)

- Flood depths 1 to 2 feet on site
- Utility power lost
- Water entered basement through communication lines
- Sump pumps kept up with water entry
- Generators remained functional until utility power restored
UTMB Galveston (Ike 2008)

- Teaching Hospital
- 84 acres 90+ Buildings
- 2/3rd campus in AE-11 rest in Shaded Zone X
- Finished Floor Elevations (FFE's)
  - 7 ft. to 15 ft.
  - 1/3rd over 12 ft.
  - Most have basements
  - Critical equipment located in basement
FEMA P-1019
Best Practices / Case Studies

Ike

- Flood elevations 12.5 ft.
- 90% buildings flooded
- 90% of damages due to flooding
- Why is this considered Success?
Best Practices / Case Studies

Flood Awareness

- Critical buildings identified
- Floor elevations documented
- Some critical equipment documented
Equipment Elevated

- Normal power (transformer)
- Emergency Power (generator)
- Critical electrical equipment (switchboard)
FEMA Flood/Wind Building Science Helpline

FEMA-BuildingScienceHelp@fema.dhs.gov

866-927-2104

http://www.fema.gov/rebuild/buildingscience