Disaster recovery: What to do after the storm

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The problem

- Rainfall or storm surge
- Harvey dumped twice as much rainfall as Katrina

Cost, economic and loss of life

Indian Ocean Tsunami (2004)
- 230,000 lives

Hurricane Katrina (2005)
- $250 billion US
- 1,800 lives

Japan Tsunami (2011)
- $309 billion US
- 18,000 lives

Hurricane Sandy (2012)
- $68 billion US
- 286 lives

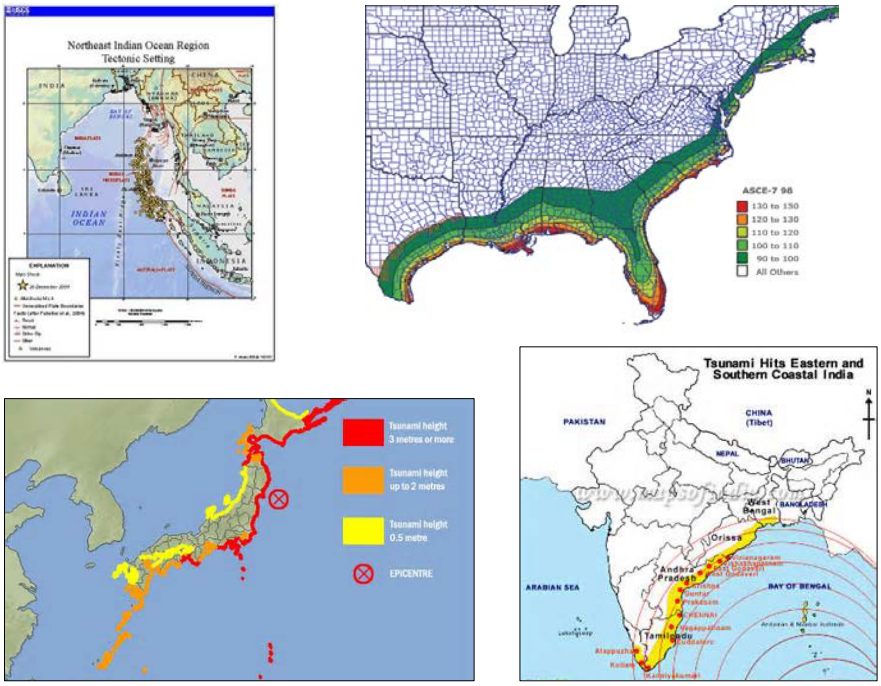
Average hurricane
- $7 billion US

Impact of hurricanes to TX and LA Gulf Coast

- Refining capacity of the US Gulf Coast is 28% of US total
- Over 400 petro-chemical facilities directly affected
- Secondary issues:
  - Displaced employees
  - Supply chain disrupted
  - Shipping / barge traffic
  - Lack of power
  - Loss of potable water

Pre-event planning

- Prioritize equipment
  - Repair
  - Replace
- Place order lists with pre-selected vendors
- Leverage vendors to carry inventory
- New construction
  - Elevate switchgear rooms
  - Store above flood stage



Prioritize electrical equipment

- Standard electric motors
  - Replace with Premium Efficient
  - Size & criticality
- Local vendors
  - Also affected
  - Develop suppliers outside affected area
- Switchgear — replace or repair
  - Availability / cost?
  - Fuses! – Replace if immersed

Emergency response team

- Form teams responsible for:
  - Replacement
  - Repair
- Coordinate shipping
  - Repairable equipment to out-of-area vendors
- Stage equipment to be replaced nearby
  - For verification of correct replacement
  - May be obsolete and require repair
  - May require inspection for insurance

Temporary housing?

Temporary living quarters

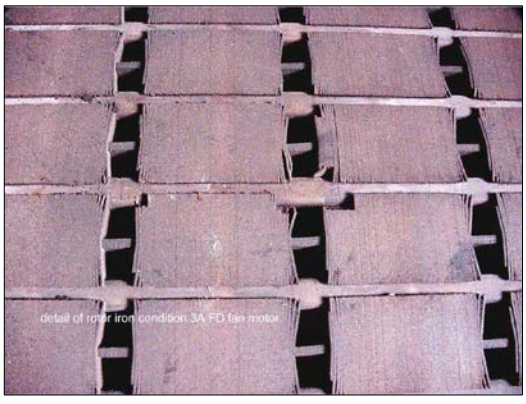
- Barge with mobile homes
- Shipping container as bunkhouse
- Cruise ship
- Merchant ships
- Potable water
- Water treatment plants are likely inoperable
- Ships as power supplier (ship to shore)
- Generators will be in short supply

Electrical equipment

- Electric motors
- Generators
- Transformers
- Switchgear
- Fuses
- Motor control centers
- Cable runs

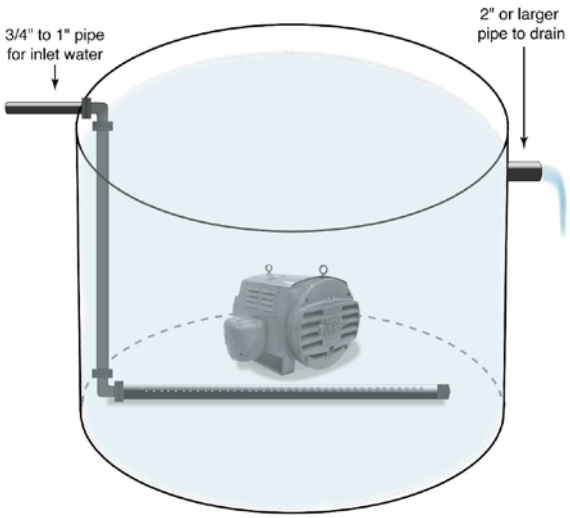
Rust caused by salt water

- **Saltwater damage**
  - Irreversible if allowed to dry
  - Immerse in fresh water



Cleaning of electric motors and generators

- Field expedient containers
  - Continuously flushed
  - Fresh water
  - 5-10 liters/minute



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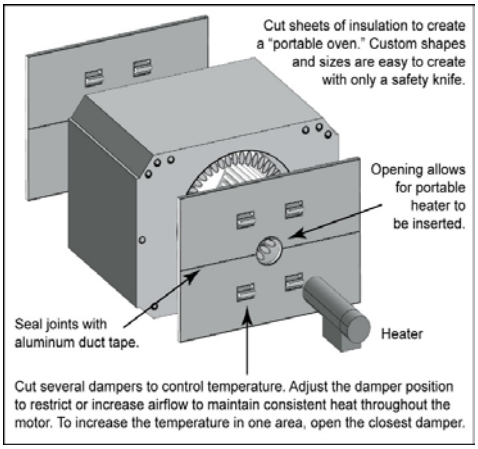
Cleaning of electric motors and generators

- Bake oven is the bottleneck
- Temporary ovens on site or at vendor



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Transformers

- Dry type
  - Process same as electric motors
  - Flush if necessary
  - Dry in oven

Transformers

- Oil-filled transformers
  - Evaluate oil condition
    - Dissolved gas analysis
    - Drain and circulate
      - warm, dry air (80-100C)
    - Inspect external cooling tubes
      - For rust
      - Clean and repaint
  - May only need exterior cleaning

Transformers

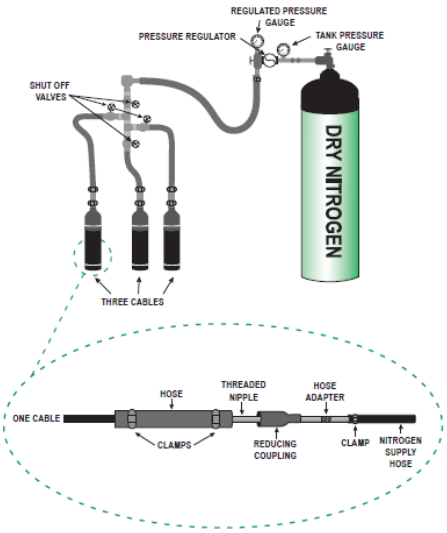
- Heat source
  - Reduced voltage closed secondary
  - Circulation of hot oil (85°C) through unit
- Units built after approximately 1965 braced for full vacuum
  - Rated 200kV or higher:
    - Vapor Phase drying is preferred
      - 35 Torr vacuum
      - Introduce hot fluid (above 100°C)
      - Flush through to absorb moisture

Distribution transformers

- "Cold trap" is essentially a still
- Dry = Less than 40 grams water in 6 hours
- Additional tests:
  - DC insulation resistance
  - Polarization Index
  - Power factor

Electrical cables

- Wet Locations
  - Conductors with "W" in the type
    - TW
    - THW
    - THWN
    - Etc.
- Conduit likely to have water
  - If buried
  - Low points
- Direct burial cable (UF or USE)
  - Exposed to saltwater
    - Expect degradation due to corrosion
- Dry cables w/dry nitrogen purge



Capital considerations

- Immersion in saltwater:
  - Significantly reduces life of laminated cores
  - Electric motors, generators and transformers
    - 5-10 years remaining service life
- Work with insurance providers for replacement/repair
- Future construction / reconstruction
  - Elevate motor control center and switchgear
  - Above flood stage

Conclusions

- Local vendors
  - Also without power
  - Inundated with work
  - Expect long delivery times
  - Expect other plants in the area to compete for resources
- Alternate vendors
  - At less convenient distances inland
  - Away from coastal flooding

Conclusions

- Natural disasters cause strain
  - Maintenance department
  - Local resources
- Plan ahead
  - Designate repair/replace
  - Coordinate & optimize shipping
  - Develop vendors
    - Inventory equipment
    - Identify replacement availability

EASA Technical Support

- If you are an EASA member and need additional technical help regarding disaster recovery involving electrical rotating equipment, contact:

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