Technologies to Prevent and Mitigate Severe Accidents

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Core Damage Prevention – FLEX and Hazard Recognition

• Understand the nature & likelihood of extreme events
  o Seismic & flooding hazard re-evaluations
  o Focus on preventing core damage

• Flexible strategies for maintaining core cooling, spent fuel cooling & containment function
  o Maximize capability of installed equipment
  o Supplement installed capability with portable equipment
  o Backup equipment from national response centers

• Research and development opportunities
  o Determine beyond design basis capability of installed equipment and possible enhancements
FLEX is Multi-Faceted

- Mitigation of Loss of Ultimate Heat Sink
- Extended Station Blackout Coping sufficient to allow initiation of FLEX
- Mitigation of Loss of Spent Fuel Cooling, includes Diverse Instrumentation
- Seismic & Flooding Walk-downs
- Process for Identifying & Assessing Impact of New Information
- EP Communications & Multi-Unit Staffing
- Diverse & Flexible Mitigation Capabilities Including Maintenance/ Guidelines/ Training/Protection
- Mitigation Beyond Design Seismic Event
- Mitigation Beyond Design Basis Flooding
- Mitigation of Other Beyond Design Basis External Events
- Mitigation of Large Fires & Explosions (Security Related)
- Additional Support Equipment from Other Plants and Regional Support Centers
- PLUS
# FLEX is a Phased Approach

<table>
<thead>
<tr>
<th>Time Line (hours)</th>
<th>0 - 4</th>
<th>4 - 8</th>
<th>8 - 12</th>
<th>12 - 24</th>
<th>24 - 72</th>
<th>&gt;72</th>
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<tbody>
<tr>
<td>Installed Equipment</td>
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<td></td>
<td>Phase 1</td>
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<tr>
<td>On-Site Portable Equipment</td>
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<td>Phase 2</td>
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<td>Off-Site Equipment</td>
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<td>Phase 3</td>
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FLEX is Defense in Depth

Staging Area Definitions
FLEX Approach is Site Specific for Electrical Power
FLEX Approach is Site Specific for Mechanical Connection
The purpose of FLEX is to prevent core damage. FLEX can still provide capability for accident mitigation if the core is damaged.
Containment Integrity/Fission Product Confinement

• Strengthen functional capability of containment
  o Containment function is to confine radioactive material
  o Enhance capability of containment to retain its design function capability
  o Maintain pressure below design limits and temperature within acceptable limits to prevent gross leakage
  o Value of water addition confirmed for Mark I and II

• Research and development opportunities
  o Evaluation of other containment designs continuing
Containment Protection & Release Reduction

Safety Benefit of Water Addition

- Base Case
- No Water
- Factor of ~3-4 Reduction
- RPV Makeup
- Drywell Makeup
- Filters

LCF Risk
IEF Risk

Exelon Generation.
Monitoring the Plant – See the Trends – Anticipate Next Steps

• FLEX maintains parameter monitoring capability
  o Lists critical instrumentation
  o Pre-plan alternatives to power instruments
  o Procedures for monitoring equipment without AC or DC power
  o Instrumentation needs overlap between core damage prevention and mitigation

• Research and development opportunities
  o Instrumentation to improve recognition of vessel breach signature; for example, thermocouples under vessel
  o Portable, remote instrumentation capability.
    – Portable remote receivers, low power requirements, no wiring through containment penetrations.
Suppress Radioactive Material Release & Transport

• If core damage prevention fails:
  o Place high priority on maintaining containment function
  o Use in containment confinement and filtering (wet containments) capability
  o Prolong containment holdup time to maximize fission product plate out & deposition

• Research and development opportunities:
  o Accident tolerant fuels
  o Forensic investigation of Fukushima will yield valuable insights
  o Core melt progression, molten debris cooling & spread behavior
Conclusions, Next Steps

• Important lessons have been learned regarding our capabilities to prevent and mitigate extreme events
• Significant safety enhancements have been made since the accident
• Our learning process can be furthered through R&D activities focused on
  o Understanding the nature and likelihood of extreme events
  o Sustaining our continuous learning process on severe accident mitigation
  o Supporting a coordinated forensic investigation of the damaged units at Fukushima