Integration of Safety in Design in MOX Fuel Fabrication Facility
Sue King

MOX Safety Fuels the Future
Sue King

- B.S. degree in Chemical Engineering from Virginia Tech
- Started her career working at the Charleston Naval Yard refueling nuclear submarines.
- Worked for the Department of Energy for about a decade in various positions at SRS and Pantex.
- Worked for the SRS M&O contractor for about a decade.
- Since 2006, she has worked for Shaw AREVA MOX Services on the MOX project. Her current position is VP of Projects.
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U.S. Pu Disposition Program

Weapons Dismantlement at Pantex

Plutonium Pits

Interim Storage at Pantex

Pit Disassembly & Conversion at Savannah River

MOX Fuel Fabrication

Aqueous Purification

Burn in Existing, Domestic Commercial Reactors

Spent fuel is unsuitable and unattractive for use in nuclear weapons

Geologic Repository

Non-Pit Plutonium

Clean Metal

Impure Plutonium Oxide

Interim Storage at SRS

MOX Fuel Fabrication Facility

Plutonium

Weapons Dismantlement

Interim Storage

Pit Disassembly

Aqueous Purification

Geologic Repository

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U.S. Pu Disposition Program
Regulatory Regime

- U.S. Congress mandated (Public Law 105-261, 17 October 1998, Section 3134) the MOX Fuel Fabrication Facility will be:
  - Licensed and regulated by the NRC
  - Comply with Occupational Safety and Health Administration Act of 1970
- DOE and NRC requirements met for Physical security
- NRC requirements for MC&A
- MOX Services is the licensee
Applicable Regulations

• 10 CFR 70, Domestic Licensing of Special Nuclear Material
• 10 CFR 20, Standards for Protection Against Radiation
• 10 CFR 73, Physical Protection of Plants and Materials
• 10 CFR 74, Material Control and Accounting for Special Nuclear Material
• 10 CFR 50 Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.
Reference Plants

Aqueous Polishing (AP)
- Dissolution
- Purification Cycle
- PuO$_2$ Conversion

MOX Process (MP)
- Powder Master Blend & Final Blend Production
- Pellet Production
- Rod Production
- Fuel Rod Assembling

La Hague
Melox
AP Reference Plant
MP Reference Plant

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Key Statistics

- Total Project Cost: $4.86 B
- Concrete: 170,000 cubic yard
- Reinforcing Steel: 35,000 tons
- Cable Tray: 47,000 linear feet
- Power/control Cable: 3,600,000 linear feet
- Process piping: 85 miles
- Gloveboxes: ~ 200
- Cells: 24
- Analytical Lab: ~85 gloveboxes
  >30,000 analyses/year
Key Milestones

- Submit Construction Authorization Request (CAR) to NRC  2/2001
- SER and NRC authorization to start construction  3/2005
- DOE authorization to start construction (CD 3)  4/2007
- Start MFFF Construction  8/2007
- End of Construction  6/2015
- Begin Hot Startup (Pu in plant)  10/2016*

*The construction schedule includes 16 months of contingency. Hot Startup is currently tracking to begin in summer of 2015.

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Construction Authorization Request

• Developed and submitted 2/2001
• ~2000 pages
• NRC issued ~250 Requests for Additional Information (RAIs)
• 4 years from time of submittal until NRC issuance of SER
  – Updated during NRC review
• Based on conceptual design and early preliminary design
• Defines safety systems at the system level
Start of Construction
August 1, 2007
Operating License Application

• Submitted to NRC 9/2006

• Document Set
  – License application (2000 pages)
  – Integrated Safety Analysis Summary (3800 pages)
  – Fundamental Nuclear Material Control Plan
  – Classified Matter Protection Plan
  – Physical Security
    • Physical Protection Plan
    • Training and Qualification Plan for Security Personnel
    • Safeguards Contingency Response Plan
  – Emergency Plan Evaluation

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Document Hierarchy

License Application
  Programmatic

Integrated Safety Analysis
  Summary
    Demonstration

Integrated Safety Analysis
  NSEs, NCSEs, HazOps, Calculations

Project Documents
  BODs, SDDs, P&IDs, Calculations, Specifications, etc
Integrated Safety Analysis

- Systematic analysis to identify
  - Internal and external hazards
  - Potential event sequences
  - Likelihood and consequences (unmitigated)
  - Identify SSCs at the component level and activities of personnel relied on to mitigate or prevent event sequences
  - Demonstrate Items Relied on For Safety (IROFS) are effective, reliable, and available to meet specified performance criteria
• Receptors
  – Facility worker (at location of hazard)
  – Site worker (100m from release point)
  – Individual Outside Controlled Area (IOC)
  – Environment

• Controlled Area boundary is about 160m from stack
• Both chemical and radiological hazards
• Must mitigate events with high consequences to “Highly Unlikely” and events with intermediate consequences to “Unlikely”
### Consequence Categories

<table>
<thead>
<tr>
<th>Consequence Category</th>
<th>Facility and Site Worker</th>
<th>Individual Outside Controlled Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
<td>TEDE &gt; 100 rem&lt;br&gt;CC &gt; AEGL3, ERPG3, TEEL3</td>
<td>TEDE &gt; 25 rem&lt;br&gt;CC &gt; AEGL2, ERPG2, TEEL2</td>
</tr>
<tr>
<td><strong>Intermediate</strong></td>
<td>100 rem &gt; TEDE &gt; 25 rem&lt;br&gt;*3 &gt; CC &gt; *2</td>
<td>25 rem &gt; TEDE &gt; 5 rem&lt;br&gt;*2 &gt; CC &gt; *1</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>Less than above</td>
<td>Less than above</td>
</tr>
</tbody>
</table>
Risk Matrix

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CONSEQUENCE

HIGH

INTERMEDIATE

LOW

LIKELIHOOD

HIGHLY UNLIKELY

UNLIKELY

NOT UNLIKELY

No IROFS

IROFS

IROFS

No IROFS

No IROFS

IROFS

No IROFS

No IROFS

No IROFS
Items Relied on For Safety Design Criteria

- Same criteria for systems protecting workers and public
- Robust design that is not susceptible to single-failure
- Consensus Codes and Standards
- Environmental qualification
- Failure detection
Additional Actions

- Perform design verification to ensure IROFS are appropriately incorporated into design
- Identify additional layers of controls for defense-in-depth
- Conduct Human Factors Engineering evaluations of administrative controls and human actions
- Update LA, ISA-S as needed during NRC review process
- Annual updates after NRC license received
Status

- Overall Project is 37% complete
- Construction is 18% complete
- NRC Review of LA to-date
  - > 100 review meetings
  - ~ 600 RAIs
    - First round of RAIs complete
  - ~$10 million billed by NRC to pay for their review time
  - No significant design changes
- SER scheduled to be complete 2010
June 11, 2009

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Conclusion

- Integration of safety into the design follows ISMS principles
  - Identify the hazard
  - Mitigate or prevent the hazard through design
  - Demonstrate that the public, workers, and environment are not adversely affected by the hazard
- Some differences from DOE regulated plutonium glovebox facility

http://www.moxproject.com