Preserving the Safety and Security at the Backend of the Fuel Cycle

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Used Nuclear Fuel Storage: Safety and Security

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Outline

• Safety and Security of Current Dry Cask Storage Systems

• Safety and Security of Transportation

• Future Challenges
  – Centralized Interim Storage
  – Used Fuel Recycling
TRANSNUCLEAR
Legacy of Performance

- Established in 1965 to transport nuclear materials in the US
- Dry storage since 1985
- Acquired NUHOMS® in 1998
- The AREVA advantage...a global network of excellence!
  - Back End Division
  - Logistics Business Unit (BUL)

More than 820 Systems Loaded as of April 2013
Safety and Security of Current Systems

• Safe to Public and Plant Personnel

• Proven Performance in Accidents
  – Earthquakes
  – Tornadoes
  – Tsunamis

• Aircraft Impact Testing
  – TN NOVA System
Dry Shielded Canister (DSC)
San Onofre
picnic lunch tables < 30’ from HSMs and 60’ from occupied buildings!
North Anna Earthquake
Fukushima Earthquake and Tsunami
Fukushima Earthquake and Tsunami
TN NOVA Aircraft Impact
AREVA Recycling Platforms in France

- Used fuel treatment
  - Extraction of valuable materials
  - Ultimate waste conditioning
- MOX fuel fabrication
- RepU fuel fabrication
- Tricastin (conversion, enrichment)
- MELOX
- FBFC Romans

Map showing locations:
- La Hague
- MELOX
- FBFC Romans
- Tricastin
- RepU fuel fabrication
Used Nuclear Fuel Transportation

- >200 transports of used fuel and vitrified, compacted waste each year
- Used fuel delivered to AREVA’s La Hague
- Incorporate physical protection systems
Recycled MOX Fuel Transportation

- >150 MOX fuel transports each year
- Fresh MOX assemblies transported from MELOX
- Transported in specially designed vehicles w/ physical protection systems
Centralized Interim Storage

- Top Priorities:
  - Safety
  - Security
- Wet or Dry?
- Standard Package, or Current Designs?
Centralized Interim Storage

- Vertical or Horizontal?
- At grade, below, or above?
- Transportation?
The Main Stages in Recycling

At each stage, nuclear material is accounted for in accordance with EURATOM and IAEA safeguards.

- **Used fuel**
- **Unloading and Interim storage**
- **Treatment operations** (shearing - dissolution - separation - purification)
- **Interim storage**
- **Recycled fuel**
- **Transported back to the customer’s country**

**Uranium**
- Universal Canister of vitrified waste (UC-V)

**Plutonium**
- Universal canister of compacted waste (UC-C)

**Fission products**
- Hulls and end-pieces

**A few years**

**A few days**

**A few years**
Types of Final (Repository-bound) Waste

The non-reusable materials are conditioned into a stable and compact form suitable for simplified transport, storage and final disposal.

- Encapsulation of Fission Products in a stable, homogeneous, and durable glass matrix with a long-term predictable behaviour.

- Compaction of structural pieces (hulls and end-pieces).

- Both the glass matrix and compacted waste are encased in a standard “Universal Canister”.

vitrification

compaction

NAYGN
The vitrified waste canisters corresponding to 40 years of French nuclear electricity production lined up side by side would occupy only one soccer field.

One of the three interim storage units on the site for vitrified canisters: EEVSE
Summary & Conclusions

• Current storage systems are robust with demonstrated excellent performance against natural and man-made hazards

• Future challenges include
  – Effects of very long storage times (≈300 years)
  – Concentration of large amounts of UNF in a single location
  – Transportation of large quantities of UNF (≈3000 MTU/year)
Your Generation Holds the Answer to These Challenges!
Questions?
Preserving the Safety and Security at the Backend of the Fuel Cycle

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North America Young Generation Nuclear Conference
May 12, 2013
Overview

• NRC Mission and Role
• SFST Role
• Waste Confidence
• National High Level Waste Strategy
• Interim Storage Facility
• Licensing Program Improvements
• Preview of Coming Attractions
NRC Mission

To license and regulate the nation’s civilian use of byproduct, source and special nuclear materials to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment.
NRC’s Role

• Principles of Good Regulation
  – Ensuring safety and security while appropriately balancing the interests of the NRC's stakeholders, including the public and licensees
  – Independence does not imply isolation
    • But collaboration does not imply collusion
  – Open channels of communication
  – Regulations should be coherent, logical, and practical
  – Regulation should be perceived to be reliable
Best Places to Work in Federal Government

• NRC ranked third out of 22 agencies that participated in the mid-size agency category last year

• In the top 3 agencies for the past several years
SFST Business Line Role

Provide licensing, oversight, and rulemaking of storage and transportation of spent nuclear fuel and transportation of other nuclear materials (e.g., medical and industrial uses)
Waste Confidence

• Top agency priority
• ISFSI renewal licensing reviews continue
  – Prairie Island
  – Calvert Cliffs
• Draft EIS, Draft Waste Confidence Decision, and Proposed Waste Confidence Rule scheduled to be issued September 2013
• On schedule for final rule by September 2014
• Plan to issue renewals soon after
National High-Level Waste Strategy and Challenges

• National strategy issued in January 2013
• Major elements:
  – Consent based process
  – Pilot interim storage by 2021
  – Full-scale interim storage facility by 2025
  – Geologic repository by 2048
• NRC is supporting the implementation within our role as independent regulator
• Draft Senate legislation
Interim Storage Facility

• Review of NRC regulations complete
• No changes required (caveat)
• At least four entities expressing some level of interest
• NRC prepared to engage in pre-selection as well as pre-application meetings
Interim Storage Facility (cont.)

- Application review not part of budget cycles pending degree of assurance regarding timing and number of potential applications
- Length of the review will depend on quality
- Much of spent fuel currently stored is not in transportable casks which may require additional licensing actions and transfer activities
- Need stakeholder input to assist licensing planning efforts
Licensing Program Improvements - Background

- **COMDEK-09-0001** (Feb 2010)
  - Undertake a thorough review of spent fuel storage and transport regulatory programs beyond 120 years

- **COMSECY-10-0007** (June 2010)
  - Plan for Near-Term Licensing and Inspection Program Improvement Review
  - Plan for Extended Storage and Transportation (EST) Program
  - Potential Policy Issues

- **SRM-SECY-09-0900** (Sept 2010)
  - Develop a Plan for a Long-Term Rulemaking to update Waste Confidence (WC) beyond 120 years
  - Integrate Plans and Resources with Staff Plans in COMSECY-10-0007

- **SECY-11-0029** (Feb 2011)
  - Plan for Development of WC EIS
  - Strategy and Prioritization for Integrating with EST Activities
  - Separates Near-Term Program Improvement Plans from broader WC/EST challenges
SRM-SECY-09-0900
Extended Storage and Transportation

• Focus on potential degradation phenomena for dry storage systems
• Consider impact on performance of safety functions
• Highest priority technical information needs
  • Stress corrosion cracking of stainless steel canisters and welds
  • Swelling of fuel over time, including fuel fragmentation
  • More realistic thermal models for longer time periods
  • Effects of residual moisture after drying
  • In-service monitoring methods
• Eight areas in next priority level include degradation processes for cladding, hardware, concrete
Licensing Program Improvements

- Retrievability and cladding integrity
- Compatibility of Part 71 and 72
- General vs. specific license requirements
- Administration of certificates of compliance
Preview of Coming Attractions

• High burnup fuel
  – NRC task force

• DOE demonstration project
  – Instrumented cask

• Licensing process changes
  – Internal process changes
  – Potential prioritization of actions
Questions
Used Fuel Storage Safety and Security

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May 2013
New Fuel

Fuel Pellet
Uranium Oxide (ceramic)
4-5% U-235 Enriched
0.45” L x 0.38” D
~300 per fuel rod

Fuel Assembly
13 feet tall
176 fuel rods
8.4 inches on side
880 lbs uranium
1350 lbs total weight
Used Fuel

- 44% of fuel assemblies replaced with new fuel every 2 years
- Fuel assembly spends 4-6 years in reactor
- Each fuel assembly produces 20,000 Megawatt-days of thermal power during time in reactor
Used Fuel - Composition

Only 60 lbs of actual waste from 880 lbs of original uranium if fuel assembly recycled.
Used Fuel – Decay Heat

Assembly Decay Heat (watts)

Time (years)
Used Fuel – Radiation Source

Unshielded PWR Fuel Dose Rate in Air

- at 1m
- at 5m
- at 10m

Dose Rate (Rem/Hour)

Time Since Discharge (years)
Wet Storage

• Used Fuel Pool
  • 6 foot thick Stainless Steel lined concrete walls and floor
  • 590,000 gallons of water
• Room for 15+ years worth of discharged fuel assemblies + full core
• Design Considers:
  • Radiation Shielding
  • Radiological Release
  • Criticality Safety
  • Decay Heat Removal
  • Structural/Seismic
Wet Storage

- Licensed for 1830 fuel assemblies at Calvert Cliffs
- Currently holds 1432 fuel assemblies
- Typically discharge 96 assemblies/year from 1 of 2 reactors
- Typically load 96 assemblies/year into dry storage
- Fuel with less than 5-years cooling time
  - 34% of fuel inventory in pool
  - 63% - 85% of decay heat load in pool (not counting full core discharge during RFO)
  - 57% of Cesium inventory in pool (from EPRI TR-1025206)
Transfer from Reactor to Wet Storage
Used Fuel Pool Layout

- **Upender Area**
  - 8’ - 0”
  - 17’ - 6”
  - 11’ - 0”

- **Rack Area**
  - 17’ - 6”
  - 8’ - 0”

- **Cask Area**
  - 9’ - 0”

- **Rack Area**
  - 54’ - 0”
  - 43’ - 3”

**CONFIDENTIAL. PROPRIETARY CENG INFORMATION. DISTRIBUTION/USE PROHIBITED WITHOUT CENG PERMISSION**
Used Fuel Pool – Criticality Safety

• Must show $k_{\text{eff}} < 1.0$ without credit for soluble boron
• With credit for limited soluble boron must show that $k_{\text{eff}} < 0.95$ unless two unlikely and independent events occur.
• Fuel Cell Pitch (Flux Traps)
• Fixed Neutron Absorber in Racks
  – Coupons or BADGER Testing for Aging Management
• For PWR only – minimum soluble boron 2000 – 2300 ppm
• Burnup Credit
Used Fuel Pool – Radiological Safety

• Shielding
  – ~9 feet of water needed above fuel at discharge to keep doses < 2.5 mrem/hr at water surface
  – 5 to 6 feet of water needed above top of rack to keep SFP deck < 100 mrem/hr

• Radiological Release
  – 23 feet of water provides factor of 200 reduction in iodine release during a fuel handling accident
Used Fuel Pool – Time To Boil on Loss of Cooling
Used Fuel Pool – Time To Uncover Fuel on Loss of Cooling
Used Fuel Pool - Emergency Planning

- **Post TMI**
  - Abnormal operating procedures for low SFP level
  - Visual reference for wide range level

- **Post-9/11**
  - Requirements to disperse recently discharged fuel heat load to air coolable geometry
  - Hardware to spray pool
  - Portable diesel driven pumps
  - Severe accident procedures for SFP

- **Post-Fukushima**
  - Wide range level instrumentation
  - Action levels
  - FLEX
Dry Storage – ISFSI

- Independent Spent Fuel Storage Installation (ISFSI)
  - 20-year License Granted in Nov 1992
  - Applied for 40-year License Renewal in Sept 2010
  - 72 HSMs Built and Loaded
  - Licensed for 120 HSMs
  - Room for 132 HSMs

- Sufficient storage space between pool and ISFSI for 60 years operation
Dry Storage - HSMs and DSCs (CCNPP)
Dry Storage - Horizontal Storage Module
Dry Storage - Transfer Cask, Trailer & Hydraulic Ram
Dry Storage – Keeping Loading Doses ALARA
Dry Storage – Aging Management