Near-Term Management of Sodium-Bonded Spent Nuclear Fuel

National Spent Nuclear Fuel Program Meeting

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Background

- ~56 MTHM sodium-bonded SNF
  - Fast Flux Test Facility (FFTF) Driver Fuel
  - Enrico Fermi Atomic Power Plant (Fermi-1) Blanket Fuel
  - Experimental Breeder Reactor-II (EBR-II) Driver Fuel
  - EBR-II Blanket Fuel
  - Sandia National Laboratory (SNL) sodium debris bed material
- Consolidated at INL
- Presents unique risks due to presence of metallic sodium
  - alkali metal reacts with water to form sodium hydroxide and hydrogen gas
  - resulting solution corrosive
  - released gas may pose pressurization and/or explosive hazard.

Background, continued

- *FEIS for the Treatment and Management of Sodium-Bonded SNF* and *ROD (*September 2000)
  - use electrochemical treatment to treat EBR-II driver and blanket, FFTF driver and SNL sodium debris bed material
  - continue to store Fermi-1 blanket while alternative treatments are evaluated
- Decision predicated on future availability/presumed acceptance criteria of Yucca Mountain
- Department announced March 2009 Yucca Mountain no longer viable disposal option
- EM formed Working Group on Sodium-Bonded SNF to reevaluate current and planned near-term actions related to the management of sodium-bonded SNF

Working Group

- Membership
  - Debbie Kula, EM-33
  - Bill Hartman, EM-33
  - Patrick Edgerton, NNSA/NA-58
  - Kerry Webb, NE-32
  - Sue Lesica, NE-54
  - Tony Marshbank, DOE ID
  - Greg Bass, DOE ID
  - Brett Carlsen, NSNFP
  - Mike Goff, INL
  - Mike Patterson, INL
  - Chuck Negin, PEC

Long-term Storage

- **Conclusion**
  - Knowledge about the effects of sodium on the material degradation of sodium-bonded SNF over a long-term period of storage is limited
- **Recommendations**
  - Direct DOE ID to propose an approach to:
    - evaluate the effects of sodium on long-term storage and methods to mitigate
    - design a monitoring program for long-term storage
  - Direct DOE ID to evaluate storage facilities:
    - For how long is the present safety basis documentation valid?
    - What changes/upgrades would be required for a significantly extended timeframe of storage and what would they cost?

Quality Assurance

- **Conclusion**
  - Maintaining demonstrable quality and configuration control of sodium-bonded SNF is essential for any disposal scenario and must be continued until ultimate disposition.
- **Recommendation**
  - Direct DOE ID to confirm that all sodium-bonded SNF is currently maintained under an audited QA program equivalent to the QARD or NQA-1. Any sodium-bonded SNF not maintained under such a program should be placed under one.

Draft Conclusions/Recommendations

FFTF driver fuel

- Moved from Hanford to INL between 2007 – 2008[1]
- Stored in NE's HFEF at MFC

- **Conclusion**
  - FFTF driver fuel in the HFEF hot cell imposes operational and potential programmatic constraints
- **Recommendation**
  - Direct DOE ID to evaluate alternatives and costs for removing FFTF driver fuel from the HFEF and recommend an appropriate course of action[2]

Notes:

1 - Unirradiated FFTF driver fuel also moved to INL (not in scope)

2 -This recommendation has been "overcome by events." See next slide

FFTF Driver Fuel – Current Status

- FY 2010 budget included $19.5M Congressionally designated funding to "prepare and treat sodium-bonded fuel within the EM portfolio."
- Plans are to use these funds to:
  - disassemble irradiated FFTF fuel in HFEF and treat in the FCF by electrochemical treatment
  - to acquire an FFTF unirradiated sodium-bonded fuel treatment system
  - to treat the unirradiated fuel in a new glovebox to be installed in the FMF
- Treatment of both the irradiated and unirradiated FFTF fuel is expected to be complete in FY 2011.

Draft Conclusions/Recommendations

EBR-II driver fuel

- Stored in EM's CPP-666 basin at INTEC

- Conclusion
  - Continued underwater storage in the CPP-666 basin poses potential leakage of water into fuel container and financial, and legal risks
- Recommendation
  - Direct DOE ID to evaluate the alternatives and costs for removing EBR-II driver fuel from CPP-666 and recommend an appropriate course of action
    - Alternatives - move to CPP-749 for long-term storage, move to RSWF at MFC for eventual electrochemical processing, others?

Fermi-1 blanket fuel

- Stored at CPP-749 at INTEC
- Should Department pursue other alternatives for treatment/disposal?

- **Conclusion**
  - Further evaluation of treatment or disposal options for the Fermi-1 blanket fuel is not warranted at this time
- **Recommendation**
  - No further work should be performed on evaluating alternatives for treatment or disposal of the Fermi-1 blanket fuel at this time.

SNL sodium debris bed material

- Stored at RSWF
- NNSA funds additional safeguards costs (~$2M/yr)
- Plan to process in ZPPR facility
  - using a technique to remove and deactivate the metallic sodium and chemically reduce the uranium oxide for subsequent electrochemical treatment.

- **Conclusion**
  - The currently planned path for treatment and disposition of the SNL sodium debris bed material should continue
- **Recommendation**
  - DOE ID should implement the current plan for the SNL sodium debris bed material, subject to availability of NNSA funding

Electrochemical processing

- **Conclusion**
  - FFTF and EBR-II driver fuels are more likely to drive up safeguards costs than blanket fuels; in addition, their treatment will be more useful to R&D.
- **Recommendation**
  - In the application of funding available for electrochemical processing, priority should be given to processing driver fuels over blanket fuels.

Future Costs

- **Conclusion**
  - Management should be aware of the potential substantial future liability incurred in choosing long-term storage over processing. In particular, implementation of proposed Graded Safeguards requirements may have significant cost and operational impacts on facilities storing some sodium-bonded SNF.
- **Recommendation**
  - Life cycle costs need to be evaluated when selecting the path forward for sodium-bonded SNF.

Path Forward

- Finalize discussion paper – early April
- Present to EM management
- Implementation memos as necessary

BACKUP SLIDES

Acronyms

ANL	Argonne National Laboratory
CPP	Chemical Processing Plant
DOE	U.S. Department of Energy
DOE-ID	Department of Energy Idaho Operations Office
EBR-II	Experimental Breeder Reactor-II
EM	Office of Environmental Management
EMT	electrometallurgical treatment
ES&H	environment, safety, and health
FAST	Flourinel Dissolution Process and Fuel Storage Facility
FCF	Fuel Conditioning Facility
Fermi-1	Enrico Fermi Atomic Power Plant
FMF	Fuel Management Facility
FFTF	Fast Flux Test Facility
FY	fiscal year
HEU	highly enriched uranium
HFEF	Hot Fuel Examination Facility
HLW	high-level radioactive waste
IFSF	Irradiated Fuel Storage Facility
INL	Idaho National Laboratory

Acronyms, continued

• INTEC	Idaho Nuclear Technology and Engineering Center
• MEDE(C)	Melt-Drain-Evaporate (MEDE); or with Carbonation (MEDEC)
• MFC	Materials and Fuels Complex
• MTHM	metric tons of heavy metal
• NE	Office of Nuclear Energy
• NNSA/NA	National Nuclear Security Administration
• R&D	research and development
• ROD	Record of Decision
• ROM	rough order of magnitude
• RSWF	Radioactive Scrap and Waste Facility
• S&S	safeguards and security
• SNF	spent nuclear fuel
• SNL	Sandia National Laboratory
• TRU	transuranic (referring to waste content)
• WAC	waste acceptance criteria
• WAPD	Westinghouse Atomic Power Division
• ZPPR	Zero Power Physics Reactor

driver and blanket fuels

- Driver fuel
  - in the center of the reactor core during irradiation
  - exposure to higher temperatures results in the sodium becoming infused into the uranium alloy and the uranium alloy bonding to the cladding
  - separation of the cladding, bond sodium, and the uranium alloy cannot be effectively achieved by a mechanical process -need to separate by dissolving the fuel elements
- Blanket fuel
  - minimal metallic sodium enters the fuel during irradiation there is no bonding between the fuel and the cladding
  - removal of the sodium is possible by thermal and mechanical methods that are simpler than dissolution