

White Paper

Options for Dry Storage Demonstration at the Idaho National Laboratory of High-Burnup Used Fuel

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INTRODUCTION

This technical evaluation investigates options for performing a dry storage demonstration of high-burnup commercial used fuel at the Idaho National Laboratory (INL) and facility modifications needed for each option. INL can provide the needed facilities to conduct the demonstration. The five primary components needed to successfully accomplish a confirmatory demonstration program are:

- A dry storage demonstration site
- A dry storage system
- A transportable package and a transportation plan
- A source of representative bounding used fuel
- Destructive and nondestructive fuel examination capabilities.

The demonstration would consist of a utility loading high-burnup fuel into a transportation package following an in-pool verification of its integrity, shipping it to INL, where it would be stored for a defined period, after which rods or assemblies would be removed for destructive and nondestructive examination of cladding and fuel pellets. Fuel retrieval and examination would be repeated at specific intervals according to an industry and lab-defined experimental plan. The dry storage system or transportation cask used for the dry storage demonstration would be modified to include instrumentation for monitoring fuel temperature and cask internal atmosphere. Instrumentation for real-time measurement of longitudinal and circumferential creep might be included.

BACKGROUND

The trend in discharge burnup level for used fuel has increased steadily since the cask demonstration and fuel examination programs of the late 1980s and early 1990s. Assembly-average burnup levels for those demonstration programs were less than 40 GWd/MTU. The current reactor operating burnup limit is 62 GWd/MTU (peak rod). Today, the majority of the used fuel discharged has burnup levels in excess of 45 GWd/MTU. Thus, in a few years, most of the used fuel going into dry storage will be at burnup levels that exceed 45 GWd/MTU. Also, used fuel of the same burnup level can be subjected to different duty cycles that can affect fuel condition. As burnup level and fuel duty increase, the knowledge base becomes sparser, and correspondingly the effects on fuel cladding integrity become more uncertain. Once DOE is in a position to take ownership of the used fuel at the plant sites, the utilities will offer the higher burnup used fuel to maximize its flexibility in managing used fuel pool capacity.

Irradiation effects and subsequent impacts are important on the used fuel cladding due to dry storage because the cladding provides the initial barrier to the release of radioactive material to the environment and contributes to maintaining the configuration of the fuel. If credit is to be taken for the cladding, there needs to be assurance that it will remain intact during storage and transportation. Therefore, it is important to know how the cladding of high-burnup fuel behaves during dry storage and transportation.

DEMONSTRATION OPTIONS GENERAL ASSUMPTIONS

For all demonstration options the following assumptions are used:

1. The demonstration cask system will be stored at the Idaho Nuclear Technology and Engineering Center (INTEC) at CPP-2707 with the other demonstration casks that contain commercial fuel.
2. Commercial fuel assemblies will be brought into INL in licensed transport casks.
3. The storage system will have a bolted removable lid and monitoring systems.
4. INTEC CPP-603 Irradiated Fuels Storage Facility (IFSF) Fuel Handling Cave (FHC) capacity is sufficient to receive the commercial-scale cask and perform the assembly and rod removal functions.
5. At INTEC, commercial fuel assembly or assemblies will be removed from the demonstration cask system. Either fuel rods or assemblies will be removed and transported to Materials and Fuel Complex (MFC) for destructive and nondestructive fuel examinations.
6. The destructive and nondestructive fuel examinations of the fuel rods will occur at the MFC in the Hot Fuel Examination Facility (HFEF) or a newly constructed fuel examination facility located at MFC.
7. Examined fuel rods will not be returned to the demonstration cask system but will be placed into retrievable storage at INTEC or MFC. The most likely facility is INTEC IFSF with a small amount kept at MFC for future research.
8. State of Idaho will allow the demonstration to occur. For a full scale demonstration of a large storage cask up to 40 Pressurized Water Reactor and 70 Boiling Water Reactor assemblies would be required. A partial scale demonstration may still exceed the mass currently allowed under terms of the agreement between the State of Idaho and the Department of Energy (DOE) (often referred to as the Batt Agreement).
9. Used fuel ownership and return policy will be agreed on by the regulatory, vendors, and utilities involved.

OPTION 1: LOADED LICENSED TRANSPORTATION AND STORAGE CASK UNLOADED AT INTEC IN THE IFSF

Option 1 involves receiving a commercial storage cask system at INTEC that is licensed for both transportation and storage of high-burnup commercial fuel. The cask will be loaded with high-burnup commercial fuel assemblies at a nuclear reactor site. The loaded cask will be shipped to INTEC for storage. After the cask has been stored for a period of time and fuel rods are needed for destructive and nondestructive examinations, the cask will be taken from its storage location and transported to the INTEC IFSF. At the IFSF, the cask will be placed in the IFSF transfer car and moved into the FHC. In the FHC, assemblies will be removed from the storage cask, fuel rods taken from the assemblies and placed in lag storage in the cell, and assemblies placed in the cask. The cask will then be returned to the CPP-2707 storage pad.

The fuel rods will be placed into a transport cask that is compatible with the receipt requirements of the MFC facilities. The cask will be transferred to MFC so the rods can be destructive and nondestructive examined. For Option 1 to be implemented, the following condition must be met:

1. The fuel storage cask must have a diameter smaller than 8 ft 7 in. and an overall length less than 18 ft to fit in the IFSF transfer car.

Beside the above condition being met the following facility equipment upgrades and modification to the IFSF would have to be made.

1. Crane alternatives will be needed at IFSF for casks weighing over 60 tons. For casks weighing over 85 tons, a hydraulic gantry system as discussed in TEV-1187 should be considered.
2. A specific insert will need to be designed and fabricated for the IFSF transfer car to support the cask during movement into the FHC.
3. For casks weighing over 60 tons, structural analysis of the IFSF transfer car would need to be performed to verify its capacity.
4. The FHC floor wells may need to be modified to store commercial fuel assemblies.
5. Remote operated tools for lifting assembly and removing fuel rods would have to be developed.

Of the NRC approved dry storage system several of the older systems could be used for this option, namely the CASTOR V/21 and TN-24 storage systems. The other approved dry storage systems are too large to fit in the IFSF transfer car or are design so that they cannot be loaded or unloaded vertically in the facility.

OPTION 2: LICENSED STORAGE CASK LOADED AT INTEC IN IFSF

Option 2 involves receiving a transport cask loaded with commercial used fuel assemblies into the IFSF and then placing the commercial fuel assemblies into a dedicated local storage cask. After the storage cask has been loaded, it will be stored with other casks at INTEC on the CPP-2707 pad. The loading of the storage cask might require multiple steps because of the limited amount of lag storage in the IFSF FHC and the number of positions being filled in the storage cask.

After the designated storage period, the cask will be taken from its storage location and transported to the CPP-603 IFSF FHC, where assemblies will be taken out for rod removal. Rods will be placed in lag storage and the storage cask will be returned to the CPP-2707 pad.

The fuel rods will be placed into a transport cask that is compatible with the MFC examination facility. The cask will be transferred to MFC so the rods can be destructive and nondestructive examined. For Option 2 to be implemented, the following conditions must be met:

1. The fuel storage cask must have a diameter smaller than 8 ft 7 in. and an overall length less than 18 ft to fit in the IFSF transfer car.

Beside the above condition being met the following facility equipment upgrades and modification to the IFSF would have to be made.

1. Crane alternatives will be needed at IFSF for casks weighing over 60 tons. For casks weighing over 85 tons, a hydraulic gantry system as discussed in TEV-1187 should be considered.
2. A specific insert will need to be designed and fabricated for the IFSF transfer car to support the cask during movement into the FHC.
3. For casks weighing over 60 tons, structural analysis of the IFSF transfer car would need to be performed to verify its capacity.
4. The FHC floor wells may need to be modified to store commercial fuel assemblies.
5. Remote operated tools for lifting assembly and removing fuel rods would have to be developed.

Of the NRC approved dry storage system several of the older systems could be used for this option, namely the CASTOR V/21 and TN-24 storage systems. The other approved dry storage systems are too large to fit in the IFSF transfer car or are design so that they cannot be loaded or unloaded vertically in the facility.

OPTION 3: LOADED LICENSED TRANSPORTATION AND STORAGE CASK UNLOADED AT INTEC IN NEW DTS

Option 3 involves receiving a commercial storage cask at the INTEC that is licensed for both transportation and storage of high-burnup commercial fuel. The cask will be loaded with high-burnup commercial fuel assemblies at a nuclear reactor site. The loaded cask will be shipped to INTEC for storage. After the cask has been stored for a period of time and fuel rods are needed for destructive and nondestructive examinations, the cask will be taken from its storage location and transported to a dry transfer system (DTS). In the DTS, the required assemblies will be removed and placed in a transport cask.

The transport cask would then be transferred to a facility to remove fuel rods from the assemblies. This would be either the CPP-603 IFSF at INTEC or the HFEF located at MFC. If the rod removal is done at INTEC, the fuel rods will be placed into the transport cask for transfer to MFC so the rods can be destructively and nondestructively examined. For Option 3 to be implemented, the following conditions must be met:

1. A DTS will be built. The DTS allows for the onsite transfer of bare spent fuel assemblies between the top-loading source cask and the receiving cask. The source cask can be a small transfer cask or a larger dry storage cask; small changes to the DTS design allow the system to be adapted to a variety of cask designs. The DRT tested in report INEEL/EXT-99-01335 was estimated to cost between \$5M and \$10M to construct.
2. The storage system cask and the small-scale transport cask will be compatible with the DTS.
3. The DTS does not have the capacity to perform rod removal.
4. Remote operated tools for removing fuel rods would have to be developed.

OPTION 4: LICENSED STORAGE CASK LOADED AT INTEC IN A NEW DTS

Option 4 involves receiving various casks loads of commercial used fuel assemblies into the new DTS and then placing the commercial fuel assemblies into a storage cask. After the storage cask has been loaded, it will be stored with other casks at INTEC. The loading of the storage cask might require multiple steps depending on which transport cask is used and the number of positions being filled in the storage cask.

After the cask has been stored for a period of time and fuel rods are needed for destructive and nondestructive examinations, the cask will be transported to the DTS. In the DTS, the required assemblies will be removed and placed in a transport cask.

The transport cask would then be transferred to a facility to remove fuel rods from the assemblies. This would be either the CPP-603 IFSF at INTEC or the HFEF located at MFC. If the rod removal is done at INTEC, the fuel rods will be placed into the transport cask for transfer to MFC so the rods can be destructively and nondestructively examined. For the above option to be implemented, the following conditions must be met:

1. A DTS will be built at INTEC. The DTS allows for the onsite transfer of bare spent fuel assemblies between the top-loading source cask and the receiving cask. The source cask can be a small transfer cask or a larger dry storage cask; small changes to the DTS design allow the system to be adapted to a variety of cask designs. The DRT tested in report INEEL/EXT-99-01335 was estimated to cost between \$5M and \$10M to construct.
2. Remote operated tools for lifting assembly and removing fuel rods would have to be developed.

CONCLUSIONS/RECOMMENDATIONS

This study identifies four options for performing a dry storage demonstration of high-burnup commercial used fuel at INL. INL has an operational facility at INTEC and MFC that can be used for the demonstration and has conducted similar demonstrations over the years. If it is decided that a demonstration is needed for high-burnup commercial, it is recommended that the demonstration be held at INL.

Modifications needed for options using the IFSF for the demonstration include upgraded of crane CRN-SF-001, new transfer car insert, and FHC floor wells to hold commercial assemblies. In addition to the modifications several structural analyses would have to be conducted to increase the loading capacity of equipment in the IFSF. Besides the analyses, remote operated tools for lifting assembly and removing fuel rods would have to be developed. Modifications needed to use a newly constructed DTS, basically consist of building the designed DTS at INTEC.

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