THE DECOMMISSIONING PATHS FOR BROOKHAVEN'S HFBR

F. Petschauer, S. Maloney, A. MacIntyre, BNL
A. Freitag, WMG, Inc.
L. Nelson, USDOE
W. Duggan, URS Corporation

ABSTRACT

In the winter of 2000, a decision was made to permanently shut down the Brookhaven National Laboratory (BNL) High Flux Beam Reactor (HFBR). Efforts to plan eventual decommissioning alternatives were then initiated in the summer of 2000. A key aspect of any alternative was to understand the various options for the dispostioning of the HFBR Vessel, Internals and Thermal Shield. Physical removal, transportation and disposal site issues posed critical decision making challenges. Options investigated, challenges addressed and decommissioning path forward decisions made for the HFBR are presented.

INTRODUCTION

The Brookhaven National Laboratory (BNL) built the High Flux Beam Reactor (HFBR) as a research tool to perform neutron scattering experiments. Neutrons generated by the reactor were directed at experimental materials to determine their crystalline structure. Figure 1 shows the timeline of the history of the HFBR. Due to a leak from the spent fuel canal reaching groundwater, the HFBR was shut down in 1997.

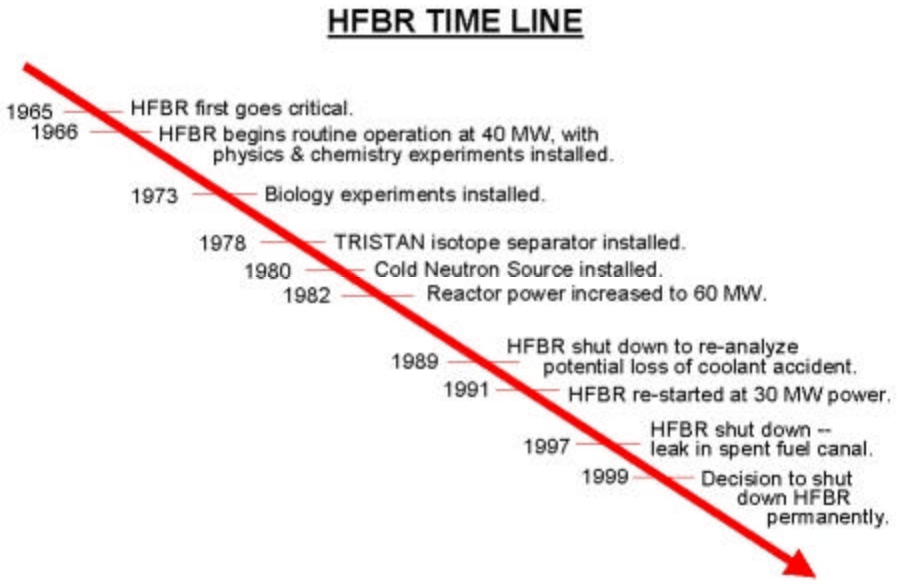

Fig. 1. HFBR Time Line

In November 1999, the Department of Energy (DOE) made a decision to permanently shut down the HFBR. Since that time, reactor technical staff has been involved in stabilization activities of the facility and, more recently, in the development of various strategies and planning for the ultimate decommissioning of the HFBR. As part of the decommissioning planning efforts, much focus has been centered on the potential methodologies available to remove and dispose of the HFBR Vessel, Internals and Thermal Shield, shown in Figure 2.

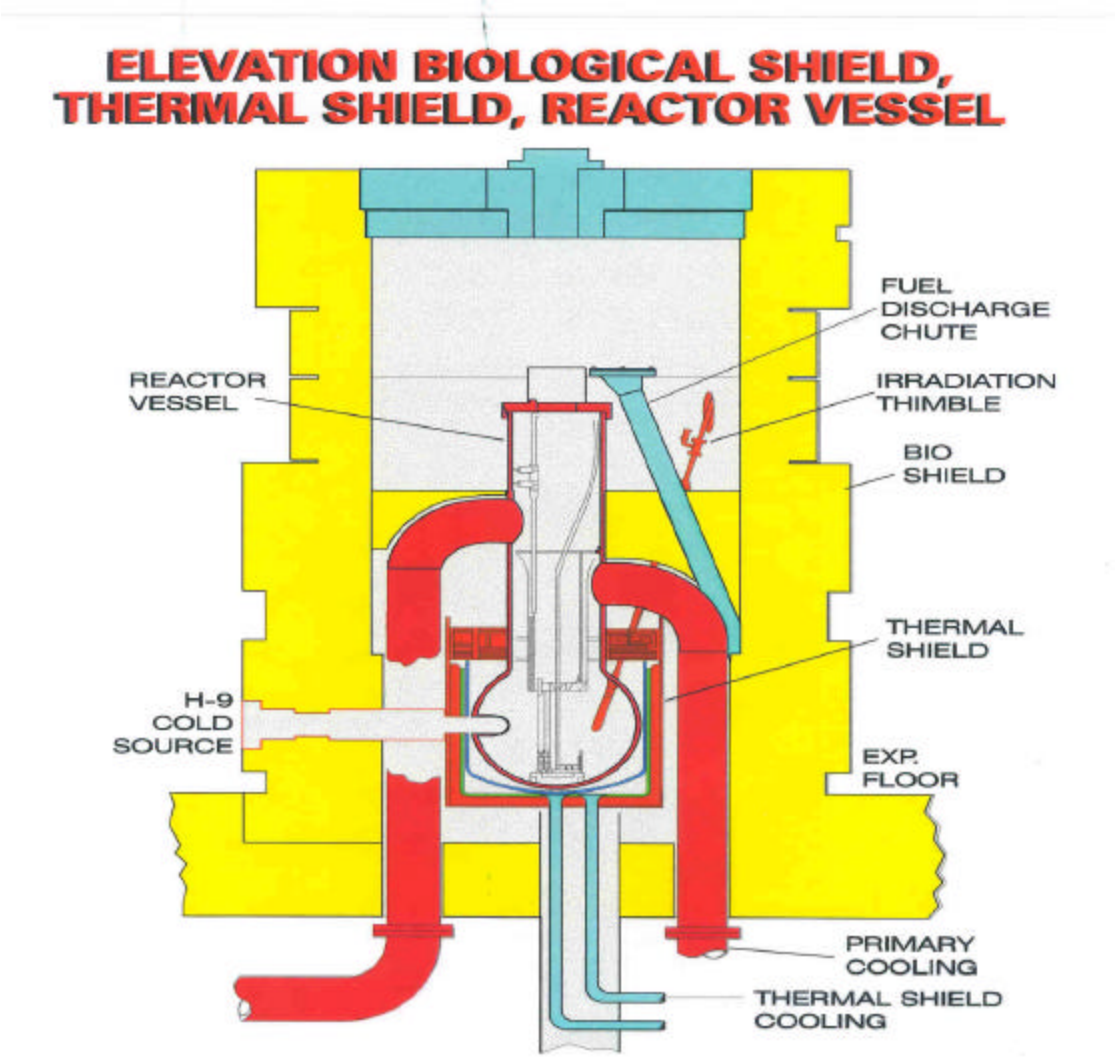

Fig. 2. Elevation Biological Shield, Thermal Shield, and Reactor Shield

The reactor vessel is shaped somewhat like a very large inverted light bulb. It is made of aluminum approximately 2 inches thick, stands 21 feet high and is 7 feet in diameter at the spherical end. It is located in the center of the building and is surrounded by heavy concrete shielding nearly 8 feet thick. The spherical end containing the reactor core is further surrounded by a lead and steel thermal shield 9 inches thick. The reactor vessel (during fabrication) is shown in Figure 3.

Fig. 3. Reactor Vessel During Fabrication

The following is a description of efforts made to date to understand and define the various options and risks associated for the dispositioning of the HFBR Vessel, Internals and Thermal Shield.

HFBR Vessel Disposition Scoping Plans

In 1999, HFBR staff wrote two specifications for contractor solicitations to develop Scoping Plans including cost estimates and risk identification. These plans were intended to address two distinct options for the removal and disposal of the HFBR Vessel, Internal and Thermal Shield. Specifically, these two options were:

- One-piece removal of the entire Vessel, Internals and Thermal Shield intact, resulting in a single shipment to a selected burial facility.
- Segmentation of the Vessel, Internals and Thermal Shield resulting in multiple shipments to selected burial facilities, as necessary.

This effort resulted in two separate vendor contracts to develop Scoping Plans. One contract was awarded to investigate the feasibility of the one-piece removal and the other was for the steps necessary to segment and dispose of the vessel, internals and thermal shield.

SCOPING PLAN CONCLUSIONS

One-Piece Removal and Disposal Scoping Plan

This plan concluded that the removal, transportation and disposal of the HFBR Vessel, Internals and Thermal Shield as a single, one-piece package is feasible. The recommended approach is to jack the entire reactor vessel, its internals and the thermal shield vertically into a specifically designed and manufactured shipping container. Grout would be placed into the package at various stages in the removal process to provide for physical stability and radiation shielding. HEPA filtration would be provided whenever grout is added to the package to address the concern of grout reacting with the aluminum vessel. The complete package would weigh approximately 200 tons. Intermodal shipping,

a combination of truck, barge and rail, would be used to transport the package to an appropriate burial facility, most likely the DOE Hanford Site located in Richland, Washington. The cost for this evolution was estimated at $18 million with a proposed accelerated schedule of 19 months to complete the project. Major risks identified included the design and licensing of the Type B package, transportation of the package and an approved burial facility.

Segmentation Removal and Disposal Scoping Plan

This plan analyzed several disposition alternatives and concluded that the segmentation of the vessel, its internals and thermal shield was not only feasible but was the preferred option when compared to one-piece removal. The suggested plan concluded that the best disposition alternative would include removal of the reactor control rod blades, segmentation of the reactor and its vessel internals, segmentation of the inner shell of the thermal shield and intact removal of the outer shell of thermal shield. The cost of this evolution was estimated at $16.9 million with a project schedule of 22 months. Added to this estimated cost is the cost of dispositioning 16 control rod blades currently located in the HFBR vessel. An estimated $1 million was added to the total project cost to account for this additional expense and for comparison of the two options. This results in a total project cost of $17.9 million. Segmentation was considered the best disposition alternative because existing licensed containers/casks would be used for packaging and transportation of waste to a disposal site. Thus, the risks associated with design, licensing and transportation of a special Type B container for the vessel is eliminated. The major risk identified was associated with the segmentation of the thermal shield.

SCOPING PLAN REVIEWS

After receipt of the two Scoping Plans, HFBR project staff initiated two independent reviews of the submitted plans. One review entailed a group of outside, nuclear industry consultants that formed a committee called the Blue Ribbon Committee. The other review included a selected group of internal BNL professional staff from various technical disciplines that formed a committee known as the Rainbow Committee.

Although each committee was given a similar yet slightly different charge, the essential directive was to make a recommendation on the best approach to disposition the HFBR Vessel, Internals and Thermal Shield. The following delineates the two committees' summary recommendations.

BLUE RIBBON COMMITTEE RECOMMENDATION

The Blue Ribbon Committee recommended adoption of the one-piece removal approach for the disposition of the HFBR Vessel, Internals and Thermal Shield. The committee performed a qualitative and a quantitative comparison of one-piece versus segmentation approach by using agreed upon comparison criteria, such as health and safety, technical, and cost and schedule. These processes formed the basis of their recommendation. At the exit presentation, the committee chairman did state that the one-piece option was chosen not as a result of eliminating the segmentation option but as the preferred option. Furthermore, the one-piece option was selected because it scored a higher on technical

and health and safety issues when compared to segmentation. Segmentation scored poorly on these criteria mostly due to uncertainty of the ability to segment the Thermal Shield underwater. The issues identified included the design, licensing and transportation of the intact vessel and thermal shield in a Type B package and with identifying a suitable disposal facility that would accept the lead with the vessel.

RAINBOW COMMITTEE RECOMMENDATION

After a thorough review of the two Scoping Plans, the Rainbow Committee determined that because of insufficient details, a preferred option of one-piece removal or segmentation could not be readily selected. The committee did state that both options were viable and that for immediate decommissioning that segmentation was recommended and for protracted decommissioning no clear choice could be recommended.

Summary Findings

From the conceptual engineering that was developed through the Scoping Plans, reviews by the outside consultant and internal review committees, and meetings and discussions among the HFBR staff, a list of summary findings and issues have been identified. These findings include:

- Both segmentation and one-piece removal of HFBR Vessel, Internals and Thermal Shield are feasible.
- Vendor-developed Scoping Plans provided a level of detail that was commensurate with their defined scope of work but additional detailed analysis and engineering are required to fully understand the risks and activities necessary to remove and dispose of the HFBR Vessel, Internals and Thermal Shield in one piece.
- Total anticipated radiation exposures to working personnel for both segmentation or one-piece approach will require further analysis to fully establish an accurate ALARA estimate.
- Questions remain regarding the embrittlement of the Thermal Shield and what, if any, impact such embrittlement would have on either disposition option.
- A definite disposal site has not been identified for the intact, one-piece vessel shipment due to the mixed waste issue regarding the activated lead located in the Thermal Shield.
- A definite transportation route has not been identified to transport the one-piece vessel package to a burial facility (assumed at this point to be DOE Hanford Site, in Richland, Washington).
- Technical questions and challenges exist for the option of segmenting the Thermal Shield.
- At this point of the HFBR Decommissioning Project, both options appear to be in the same cost range of $18 million although it is recognized that a more detailed cost estimate is warranted.
- Any estimated schedule for one-piece removal is at risk due to an unknown cask licensing duration (DOE and NRC), burial site availability and an acceptable transportation route.

- Segmentation operations may begin within a short period of time (six months). One-piece removal will require a protracted timeframe due to time needed for a single large procurement, detailed engineering, facility modifications and shipping cask design, licensing and fabrication.
- The one-piece removal option poses more destruction to the HFBR Reactor Building. This potential destruction would, in turn, result in a more restricted and/or more expensive building future use options.
- Segmentation of HFBR Internals and the inner liner of the Thermal Shield will require use of the newly double wall lined spent fuel storage canal. Use of this canal (which has been provided with a new liner) will present some non-technical issues due to the canal leak that occurred in 1997. Other transfer and waste handling options exist but radiation exposure and schedule delays would make such options much more difficult.

HFBR Reactor Vessel Dispositioning Path Forward

At this time, it is premature to either select a vessel alternative or to eliminate one alternative based on the information or lack of information that currently exists. BNL is pursuing the following tasks that will serve to eliminate an alternative or to establish an acceptable confidence that the alternative chosen will be successfully achieved.

SEGMENTATION TASKS

Flooding of the Bioshield Cavity

Given the current calculated radiation dose rates of the Thermal Shield (as high as 5,000 R/hr), the only reasonable environment to segment this activated component is under water. HFBR staff has been reviewing historical information regarding efforts to flood the Bioshield cavity. Additionally, the HFBR staff is performing conceptual engineering to provide for a leak tight flooding of this cavity. The initial outlook is that there is strong creditability that the flooding, in a leak tight environment, of the Bioshield Cavity is feasible. This condition would allow for the remote underwater segmentation of the Thermal Shield in accordance with Health Physics ALARA practices.

Work Step List for Vessel Segmentation

Along with performing the conceptual engineering to flood the Bioshield cavity, HFBR staff is developing a work step list for the entire segmentation of the vessel, internals and thermal shield. This procedure will serve as a basis to perform a Job Safety Analysis (JSA). The JSA is intended to identify any hazard during the segmentation evolution and to provide mitigation controls, either administratively or physically, to prevent any accidents to workers or the environment.

At the completion of the JSA process, HFBR staff will present the work step list and the JSA to the BNL Safety Committee. Concurrence with the approach will be sought and, if successful, a continuation of the planning and engineering for segmentation may proceed. Such a continuance will consider a full-scale mock-up of the Bioshield cavity to

demonstrate the eventual cutting technology and provide a "real world" work environment to plan all work activities.

Confirmation of Thermal Shield Dose Rates

Activation analysis originally performed on the Thermal Shield has calculated an expected radiation dose rate of 5,000 R/hr. The HFBR staff is reviewing all information to check previous calculated dose rates. Initial indications are that contact dose rate of the inner Thermal Shield may be lower by half or less (approx. 2,000R/hr) from the original calculated dose rate with better information.

To further ascertain radiological conditions of the Thermal Shield, HFBR staff is in the process of obtaining empirical dose rates through the use of specially configured radiation detectors placed through tubes in the region of the Thermal Shield. Once these empirical dose rates are obtained, comparison against calculated values will allow for more confidence in the expected dose rates of the Thermal Shield. Such data correlation and coordination will also allow for a higher level of predictability in estimated personnel radiation exposures.

ONE PIECE CONFIRMATION TASKS

In parallel to efforts above, HFBR staff is proceeding with efforts to more clearly define and address risks associated with the one-piece removal option. These efforts include:

Thermal Shield Embrittlement Study

In order to determine if the Thermal Shield is subject to brittle fracture, under a number of work activity scenarios, a BNL metallurgical and subject matter expert to conclusively document the material condition of the Thermal Shield and to determine under what conditions this structure can be safely handled. Such information will be valuable to any proposed lifting operations of Thermal Shield and may be part of any specification to solicit proposals for one-piece removal.

Access to a Burial Facility

A the present time, access to a burial facility for a one-piece HFBR Vessel, Internals and Thermal Shield package is not available. HFBR staff is monitoring existing burial facilities and tracking changes in regulatory requirements, and will prepare requests, as appropriate, to determine if the disposal of the HFBR one-piece package including the activated lead (Thermal Shield) will be acceptable for burial.

Available Transportation Route

At this time there are many issues associated with the transportation of a one-piece package. The assumed burial facility is the DOE facility located at the Hanford Site in Richland, Washington. Transportation by rail from BNL, located on Long Island, New York, through New York City is not allowed. In addition, identification of a water dock for a barge shipment to a suitable connecting port has not been made, and even land

transportation from BNL has questions regarding road weight limitations due to the anticipated payload of 200 tons. HFBR staff will pursue the development of a transportation plan for the one-piece shipment. Additionally, project staff will monitor any proposed transportation routes of the spent fuel from the Brookhaven Medical Research Reactor to Savannah River. This monitoring will provide an awareness of potential transportation routes off Long Island.

CONCLUSION

In the early part of 2001, significant additional information will be known about the viability of segmenting the HFBR Thermal Shield in a radiological safe manner. Technical issues for this work activity will be better understood and the associated risks for this work will have had a first level screening by the BNL Safety Committee. Although the referenced timeframe will not be the final decision point for the underwater segmentation of the Thermal Shield, it will represent a point where it could be recommended to advance the engineering efforts for the segmentation option. Conversely, if the preliminary engineering and safety analysis identifies insurmountable technical and health and safety concerns, then the segmentation option need not be pursued further.

If the segmentation option is determined viable, existing HFBR staff will be able to develop plans for detailed engineering for segmentation of the vessel, internals and the thermal shield. Dependent on DOE funding profiles for subsequent fiscal years, preparation to remove core internals, such as Control Rod Blades can begin, testing and preparations for the eventual water filling of the spent fuel canal can be performed, and planning and eventual fabrication of a Thermal Shield mock-up may start.

During the near term timeframe, HFBR staff will pursue the following activities:

- Public input from workshops will be obtained for the various options to disposition the HFBR Vessel, Internals and Thermal Shield.
- Investigation of, a) the segmentation tasks to conclude that the dose rates support an acceptable cutting environment, b) the flooding of the Bioshield cavity can be performed in a leak tight environment, and c) a method to cut or remove the Thermal Shield can be confidently deployed.

While efforts are focused on the segmentation option, HFBR staff will continue to address and monitor the major risks associated with the one-piece removal option, namely burial site access, transportation routes and cask licensing. If the prerequisites for segmentation are inconclusive, plans will be developed, in parallel to segmentation plans, to pursue the engineering and other tasks associated with the one-piece removal option.