Brookhaven Graphite Research Reactor
Graphite Removal Technical Exchange Workshop
May 9-10, 2007
Brookhaven National Laboratory

Lessons Learned Summary Document

Table of Contents

Brookhaven Graphite Research Reactor (BGRR)
Graphite Removal Technical Exchange Workshop
May 9-10, 2007
Brookhaven National Laboratory
Lessons Learned Summary Document

1.0 Introduction

The Department of Energy (DOE) is conducting final decommissioning of the Brookhaven Graphite Research Reactor (BGRR) located at the Brookhaven National Laboratory (BNL) in Upton, New York. The Environmental Management Office of D&D and Facility Engineering sponsored a workshop May 9-10, 2007, at BNL, that brought together four international Subject Matter Experts (SMEs) in graphite reactor decommissioning, cognizant BNL DOE and Brookhaven Science Associates (BSA) personnel, and interested parties from other DOE programs and field sites to share plans and relevant experience (see Attachment A, Memorandum of Invitation). The purpose of the workshop was to discuss lessons learned and experience gained (i.e., technology transfer) from the deactivation and decommissioning of other graphite reactors, with the goal of informing ongoing planning and near-term execution, and resulting in a more efficient, safer, and cost-effective project. Topics discussed included worker health and safety; risks and hazards identification; robotics; and materials characterization, handling, and disposition (see Attachment B, Workshop Agenda).

1.1 Background

The BGRR was the world's first research reactor constructed solely for the peaceful use of atomic energy. The BGRR operated from 1950 to 1968. In 1972, defueling and off-site shipment of the fuel was completed. Beginning in 1998 and continuing through 2005, several interim measures involving removal of contaminated structures, components, and soils were completed. The BGRR Record of Decision (ROD) was approved on March 17, 2005. The remedial actions in the ROD included these interim actions completed through 2005, and the remaining work which includes:

- Removal of the graphite pile;
- Removal of the biological shield (bio-shield);
- Transportation and disposal of all project wastes;
- Installation of an engineered barrier around the BGRR reactor building; and
- Final cleanup of the reactor facility including documentation of the as-left conditions.

This remedial work is being performed as an Environmental Management Completion Project (BEMCP) under Area of Concern 9 of the BNL Interagency Agreement. BSA is DOE's prime contractor for completion of the Brookhaven BEMCPs.

1.2 Current Plans for D&D

The initial presentation of the workshop was given by BSA and described the decommissioning actions to date, current condition of the BGRR facility including characterization data, and planned D&D and waste management activities.

The fuel was removed previously from the BGRR reactor leaving behind approximately 60,000 blocks of contaminated graphite (formerly the reactor core), and a steel and concrete bio-shield. The steel portion of the bio-shield, especially the inner portion, contains significant quantities of neutron activation products and tritium. The graphite contains residual contamination as well as residues from failed uranium fuel assemblies. BSA has carried out an extensive program to characterize both the graphite and the bio-shield.

BSA plans to prepare a Statement of Work for subcontracting the disassembly of the graphite core and the bio-shield. The selected contractor will:

- Remove 1000 lb. of Cd-coated boron shot, used as an emergency moderator;
- Remove the reactor's 16 control rods;
- Remove the shield plugs above the reactor core;
- Remove air membrane above the reactor core;
- Remove the graphite blocks;
- Remove the bio-shield; and
- Ship the waste to either Nevada Test Site (NTS) or Energy Solutions, depending on the level of activity.

BSA's current planning concept is to remove the shield plugs and then use a robotic platform to remove the graphite. The bio-shield will be taken apart using mechanical cutting techniques. All materials will be loaded into 144 ft^3 boxes, for eventual shipment to either NTS or Energy Solutions (in Utah). Approximately 10% of the boxes will undergo confirmatory assays; the activity levels reported for waste boxes will be based primarily on scaling factors derived from knowledge of the BGRR's operating history and from BSA's characterization of the materials.

2.0 Workshop Discussions and Recommendations

The Office of D&D and Facility Engineering invited four international subject matter experts (see Attachment C for list of SMEs) to present their experiences relating to graphite reactor D&D (a CD of the workshop presentations and video tape of the workshop are available), and to participate in a question-and-answer session with the BNL DOE and BSA personnel and workshop participants. The SMEs have extensive experience with United Kingdom (UK) graphite reactor D&D. A fifth SME, who provided his presentation but could not attend the workshop, consulted extensively during the D&D of the Ft. St. Vrain graphite reactor.

The workshop discussions were open and wide-ranging and the BSA team indicated that they appreciated the opportunity to learn from the SMEs. BSA intends to incorporate "lessons

learned" into the decommissioning plans for the BGRR. SME recommendations for disassembly of the BGRR graphite core and bio-shield are summarized below by technical area.

2.1 Characterization / Mock-ups / Modeling

Based on the information presented, the SMEs concluded that the BGRR graphite pile is generally well characterized. However, the SMEs pointed to the potential for unexpected levels of actinides from failed fuel, and of C-14 in activated carbon steel from the bio-shield as issues that might impact acceptance of the waste by NTS. In addition, the SMEs suggested that BSA carry out further nuclear modeling to provide some backup for the reactor as a whole, using the Co-60 inventory to back-calculate the neutron flux, and from that to calculate other radionuclides based on generic precursor data.

The SMEs believed that mock-up testing and operational modeling of disassembly operations are essential and would be beneficial - first as computer generated sequences and then through actual mock-ups to physical test procedures, tool performance and recovery methods. These activities had proven most beneficial especially during D&D of the Windscale Advanced Gas Reactor. One of the SMEs commented that the goal should be to turn demolition and debris removal into a specifically sequenced number of repetitive steps.

In addition to doing modeling and mock-ups of the pile, it was recommended that modeling of the surrounding areas be conducted. This is useful to understand such things as, but not limited to, clearance needed by load rotation units on remote hoists. Finally, the use of multi-camera views, especially for remote operations was emphasized.

2.2 Potential Hazards

The SMEs agreed with BSA that removal of the graphite should be straightforward, and not overly difficult. Both the SMEs and BSA agreed that graphite dust explosions are not credible under normal work circumstances, and that Wigner energy[1] should also not be a concern. One of the SMEs pointed out that while release of Wigner energy should not be a problem during processing, it might cause a problem if waste boxes were grouted in the disposal facility due to heat generated during the curing of grout.[2]

2.3 Cutting Technologies

Based on the SMEs' experience, removal of the bio-shield is likely to be a much greater challenge than removal of the graphite. There was concern that size reduction of the bio-shield

---

[1] Graphite, when bombarded by neutrons, can suffer dislocations in its crystalline structure causing a build up of potential energy, called Wigner energy. An annealing process is a means of safely and gradually releasing this stored energy from the graphite.

[2] Problems can occur, including fires, if there is a sudden Wigner energy release. Discussions with NTS waste disposal personnel, however, indicated that there are no plans for grouting the disposal cells, although grouting could be an option for long term closure. This potential issue should be well documented at the NTS for future reference and considerations.

by mechanical cutting techniques would be complicated by the size of the cutting tools required, and by the need for very robust mounting systems to prevent excessive cutting tool failures due to the reaction forces involved. The inner steel wall on the bio-shield will be especially troublesome because of the much higher levels of activation products in this material, and the welded nature of this wall. Similarly, there was some concern that the metal plates that make up the BGRR air membrane would also be highly activated. The SMEs strongly urged BSA to mockup potential technologies, perhaps even including as part of the procurement.

The SMEs recommended that BSA reconsider its position on thermal cutting technology. Although thermal cutting can be somewhat "dirty", these technologies were generally much simpler to deploy than mechanical methods, and the SMEs felt that there were ways available to mitigate any potential effects. If BSA reconsiders the use of thermal cutting, an offer was made to help establish contacts with the Belgian SMEs who have significant experience at the BR3 reactor facility (where a high pressure water jet cutting device was successfully utilized for size reduction). A paper presented at the Waste Management 2005 conference entitled "Research and Development Results for Dismantling and Decontamination Applications" (R. Versemann, et al) should also be reviewed for potential applications.

2.4 Schedule / Contingency Planning

The SMEs were concerned that the overall schedule seemed optimistic. The SMEs did not believe that graphite removal posed serious problems, other than the process time involved in removal of 60,000 individual blocks. They recommended that a system for multi-block handling be developed, and extensively tested in mockup demonstrations. The SMEs have experience with vacuum pads and drill-and-tap removal technologies that have worked well in the field, and their application was both discussed and demonstrated through brief video clips.

There was a concern about an apparent lack of detailed contingency planning. BSA indicated that they would require its contractor to do the planning, but by constraining the technologies to be used (e.g., use of mechanical cutting only), BSA may be limiting the contractor's ability to work around operational problems. In that regard, the Safety Basis must be sufficiently robust to provide enough flexibility to rapidly respond to unforeseen situations. Thus, BSA must be an "intelligent customer."

3.0 Next Steps

It is anticipated that if the information provided (lessons learned) is incorporated into current thinking, significant benefits for planning and initiating the physical dismantlement of the BGRR graphite reactor core and bio-shield will be gained.

The BSA team indicated that the workshop was an overall benefit to the BGRR decommissioning mission, confirmed identified non-issues such as Wigner energy, highlighted key areas warranting attention/focus, and will be extremely valuable as they transition into detailed planning for the project. These topics/ key areas include:

- Wigner energy and graphite dust explosion should not be an issue;

- Graphite blocks remain intact during removal and block seizing should not be an issue;
- Industrial hazards purely germane to graphite handling (e.g., slipping hazards) were not onerous and could be worked around by provision of the correct personnel protective equipment;
- Airborne graphite dust and impacts to ventilation systems/HEPA filter banks should not be significant issues;
- Segmentation and removal of steel components is much more of a challenge than graphite and concrete removal;
- Thermal and mechanical segmentation alternatives for steel components is much more of a challenge than graphite and concrete removal;
- Process/special tool simplicity is a key success factor; and
- Mock-ups and rigorous qualification of special tools by inactive testing and staff training procedures are essential key success factors;

Also, the BSA team has examined the project schedule for the design and qualification of the special tools that will be used to segment steel components and have concluded that more should be done in front-end loading these activities to provide sufficient time for testing and qualifying this equipment. This will be reflected in the draft baseline that will be submitted to DOE BNL this summer, and in the procurement specifications for the biological shield removal. The BSA team will also work with the Independent Review Panel to re-examine the plan to limit interior biological shield segmentation to non-thermal methods.

DOE F 1325.8
(8-89)
EFG (07-90)

United States Government **Department of Energy**

memorandum

APR 1 3 2007

DATE:

REPLY ATTN OF: EM-23 (S. Frush, 301-903-8159; A. Szilagyi, 301-903-4278)

SUBJECT: Brookhaven Graphite Research Reactor (BGRR) Graphite Removal Technical Exchange Workshop, May 9–10, 2007, at Brookhaven National Laboratory (BNL)

TO: Distribution

The Office of Engineering and Technology (EM-20) invites you and/or your staff to attend the BGRR Graphite Removal Workshop scheduled for May 9-10, 2007, at the BNL site. The purpose of the workshop is to discuss lessons learned and experience gained (i.e., technology transfer) from the deactivation and decommissioning (D&D) of other graphite reactors. Topics to be discussed include, but are not limited to, the functional areas of health and safety, risks and hazards identification [nuclear, chemical, and physical (graphite dust, Wigner Energy, etc.)], material handling, robotics, and material disposition. Several international subject matter experts will present their experiences relating to graphite reactor D&D and will participate in a question-and-answer session. It is anticipated that the lessons learned discussed at this workshop will be beneficial for planning and initiating the physical dismantlement of the BGRR graphite reactor core. In addition, although many of our sites do not have graphite reactors, the lessons learned discussion pertaining to remote technologies would be useful for all D&D staff. The target audience for this workshop includes the BNL Federal and Brookhaven Science Associates staff and any appropriate subcontractors; however, other interested parties are welcome to attend.

Please RSVP to Sandra Waisley (sandra.waisley@em.doe.gov) by April 27th if you and/or your staff would like to attend the BGRR Graphite Removal Workshop. In addition, Dr. John Plodinec, from the Savannah River National Laboratory, is supporting my office in the planning and implementation of the workshop. Please contact Dr. Plodinec at (803) 725-1134 for more information or if you have any questions regarding workshop logistics. An agenda will be sent to workshop attendees when finalized.

I look forward to seeing you at the BGRR Graphite Removal Workshop.

Mark A. Gilbertson
Deputy Assistant Secretary for
Engineering and Technology
Office of Environmental Management

Distribution:
Mark W. Frei, Deputy Assistant Secretary for Planning and Budget, EM-30
Jack Surash, Deputy Assistant Secretary for Acquisition and Project Management, EM-50
Dae Chung, Deputy Assistant Secretary for Safety Management and Operations, EM-60
Cynthia Anderson, Director, Site Support and Small Projects, EM-3.2
John Sattler, Acting Director, Brookhaven Federal Project Office (BNL)
Jack Craig, Manager, Consolidated Business Center Ohio (CBC)
George Malosh, Chief Operating Officer, Office of Science, SC-3
Mike Holland, Manager, Brookhaven Site Office (SC-BHSO)

cc:
Charles E. Anderson, Principal Deputy Assistant Secretary for Environmental Management, EM-2
Dr. Ines Triay, Chief Operating Officer, EM-3
Keith A. Klein, Manager, Richland Operations Office (RL)
Shirley Olinger, Acting Manager, Office of River Protection (ORP)
Jeffrey M. Allison, Manager, Savannah River Operations Office (SR)
William E. Murphie, Manager, Portsmouth/Paducah Project Office (PPPO)
Steven Feinberg, Director, Separations Process Research Unit (SPRU)
Bryan Bower, Director, West Valley Demonstration Project Office (WVDP)
Elizabeth D. Sellers, Manager, Idaho Operations Office (ID)
Richard B. Provencher, Assistant Manager, Idaho Operations Office (ID)
Gerald Boyd, Manager, Oak Ridge Office (OR)
Steve McCracken, Assistant Manager, Oak Ridge Office (OR)
Dr. John Plodinec, SRNL

Brookhaven Graphite Research Reactor Workshop

Brookhaven National Laboratory
Building 555 (Chemistry), Hamilton Seminar Room

May 9-10, 2007

PURPOSE OF WORKSHOP

This workshop will provide the results of efforts to dismantle and demolish graphite reactors to Brookhaven to assist in project planning and execution. It will also provide opportunities to glean the lessons learned from several graphite reactor D&D projects from the people who performed, in area such as:

Characterization.
Special hazards (e.g., Wigner energy, dust, pyrophorics).
Graphite handling, and special tools.
Debris removal and packaging.
Planning.
Waste package assay.
Worker safety.

SUBJECT MATTER EXPERTS

Martin Cross, Nukem, UK
Ed Perrott, formerly of Nukem, UK
Mark Steele, Deputy Site Director, Hinkley; Reactor Sites Management Co
Michelle Wise, Head, Technical Services Group, UKAEA
Paul Woollam, formerly of Magnox, UK

Brookhaven Graphite Research Reactor Workshop

Brookhaven National Laboratory
Building 555 (Chemistry), Hamilton Seminar Room

AGENDA
May 9, 2007

08:30-09:00	Badging	
09:00-10:30	Tour of facility for SMEs	
10:30-10:45	Welcome Introduction, and agenda	Sandra Waisley, Office Director, EM-23 Andrew Szilagyi, EM-23
10:45-12:00	BGRR facility; current plans for D&D	Fred Petschauer, BSA
12:00-13:30	Lunch	
Lessons Learned from Previous Graphite Reactor D&D Projects		
13:30-14:30	Windscale Piles	Martin Cross
14:30-15:30	Methods development for WAGR (Windscale Advanced Gas-cooled Reactor)	Ed Perrott
15:30-15:45	Break	
15:45-16:45	WAGR, Pile 1, and other projects	Mark Steele

Brookhaven Graphite Research Reactor Workshop

Brookhaven National Laboratory
Building 555 (Chemistry), Hamilton Seminar Room

AGENDA
May 10, 2007

Lessons Learned from Previous Graphite Reactor D&D Projects (continued)		
09:00-10:00	Graphite Low Energy Experimental Pile; British Experimental Pile	Michelle Wise
10:00-10:15	Break	
10:15-11:15	Magnox, Ft. St. Vrain experience	Paul Woollam
11:15-12:00	Questions from audience	John Plodinec, Moderator
12:00-13:30	Lunch	
13:30-15:00	Subject Matter Expert views	John Plodinec, Moderator
15:00-15:15	Break	
15:15-16:00	Wrap-up; workshop ends	

List of Subject Matter Experts

1. Dr. Martin Cross, Nukem, UK
2. Edwin Perrott, formerly of Nukem, UK
3. Mark Steele, Deputy Site Director at Hinkley A, Southern Reactors Decommissioning, British Nuclear Group
4. Michelle Wise, Head, Technical Services Group, UKAEA
5. Paul Woollam, formerly of Magnox, UK (Paul prepared a presentation, but did not attend the workshop)