November 22nd, 1997

Dr. Martha Krebs, Director
Office of Energy Research
U.S. Department of Energy
Washington, D.C. 20585

Dear Dr. Krebs:

This letter is to report the recommendations of BESAC in response to your charge to us of June 23rd relating to the current shutdown of the High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory.

As you are aware, this was the sole item of business at our recent meeting in Gaithersburg on July30th - August 1. At this meeting, we were advised of the conclusions of the prior meeting of the DOE/ER Ad Hoc Committee to Review the Cost and Schedule of High Flux Beam Reactor Restart, and we noted that the restart could be achieved without a significant impact on the expenditures of the Office of Basic Energy Sciences. Subsequent to our meeting, we received the Report of this Committee.

In particular, it was reported that the DOE/ER Committee had considered three options:

(1) Restart at 30 MW with necessary modifications to address safety and regulatory requirements prior to restart and with no further analysis under the National Environmental Policy Act (NEPA).
(2 Restart at 30 MW with future operation up to 60 MW with necessary modifications to address safety and regulatory requirements prior to restart and with a full Environmental Impact Statement (EIS) prior to restart.
(3) Shut down and place in a SAFESTOR condition in preparation for future decontaminating and decommissioning (D&D).

We were also told that the DOE/ER Committee had recommended that the second option seemed the most reasonable, in that restarting without an EIS was unlikely to be acceptable. The cost estimates for restart were presented in sufficient detail to facilitate an assessment of their reasonableness, and that with a few minor exceptions they were considered sound and reasonable. However, they also pointed out that they had assumed that funding would be available on October1st, 1997; and that delays in starting would impact the estimates.

In the event that a full EIS was undertaken, it was further assumed that it would take 15 months with a further month waiting period for the Record of Decision; delays here would also impact the costs.

The costs of D&D were uncertain but likely to be high.

Some tasks will be necessary whatever option is selected: these include the installation of a liner in the fuel pool; the installation of double-walled piping; the modification of the exhaust stack drain piping; and resealing floor joints and penetrations.

The schedule as presented to us showed that if a full EIS was undertaken, the critical path was made up of a sequence of two major items: the EIS, followed by some components of a seismic upgrade, which would be required for options (1) and (2), but not for option (3). There was some debate about the time required for an EIS, but we were told that new procedures had been introduced which would allow an EIS to be completed in the 15 months quoted. The sequential nature of the elements of the seismic upgrade (the fabrication and installation of the structural steel sections, and (not on the critical path but close to it), the fabrication and installation of fixtures), we were advised, is because it is not allowed to start on physical modifications of this type while an EIS is underway.

On the basis of this information, the Committee concluded that there were no major financial or timing obstacles which would impact our decisions, provided of course that the optimistic schedule could be achieved. We also agreed that a full Environmental Impact Statement should be undertaken; an important factor in this recommendation is the need to reassure the local community.

The remaining part of the meeting was concerned with the technical aspects of the HFBR. As you know, there is a considerable recent history relating to neutron sources, and the part that neutron science plays for the scientific and technical community in the United States. The Seitz-Eastman Committee in 1984 showed the importance of neutron scattering research in materials research and related disciplines, with the construction of a large new neutron source having the second highest priority after an Advanced Photon Source; and the January 1993 report from the BESAC Panel on Neutron Sources chaired by Professor Walter Kohn emphasized the importance of completing the design and construction of the reactor-based Advanced Neutron Source (ANS). This report also reviewed in detail the applications of an advanced neutron source, drawing from the review of Neutron Sources and Applications held in Oak Brook, Illinois, in September, 1992; the Proceedings of this review, edited by D. L. Price and J. J. Rush were published in January1994. Unfortunately, in 1995 Congress concluded that ANS was not economically feasible in the foreseeable future, and recommended instead the design and construction of a next generation pulsed spallation neutron source. This immediately raised a question about how to support the important scientific and technical needs identified by the Kohn Committee which could optimally or uniquely addressed by steady state neutron sources. A BESAC Panel was appointed to address this specific issue under the chairmanship of Professor Robert Birgeneau, and reported to BESAC in January, 1996. Their conclusions were reported to you by the then Chairperson of BESAC, Professor Carl Lineberger, as an interim report in his letter of March10th, 1996.

In reference to the High Flux Beam Reactor, the recommendation was:

"The High Flux Beam Reactor (HFBR) at Brookhaven National Laboratory must be upgraded to obtain essential neutron scattering facilities for the nation's research

community. It is estimated that the upgrade can be accomplished for an incremental cost of $150 M, but there are very substantial uncertainties in this estimate. A full conceptual design will be required before the cost can be better estimated and before the public reaction to this project can be assessed. BESAC recommends that a conceptual design for the high flux beam reactor upgrade be initiated as rapidly as possible, to establish a firmer cost basis. If the total cost remains as estimated, then DOE should proceed with the HFBR upgrade as a cost-effective method to provide cold neutron scattering facilities."

In our discussions, we based our debate on these various points outlined above.

We were presented with a series of brief reviews of the larger current U.S. neutron facilities:

Reactor-Based Sources:
The High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory;
The Neutron Beam Split Core Reactor (NBSR) at the National Institute of Standards and Technology (NIST)
The University of Missouri Research Reactor Center (MURR)

Accelerator-Based Spallation Sources:
The Los Alamos Neutron Scattering Center (LANSCE) at Los Alamos National Laboratory;
The Intense Pulsed Neutron Source (IPNS) at Argonne National Laboratory

We were also briefed on the current status of the National Spallation Neutron Source.

Finally, in this review of alternative facilities, we were briefed on the major centers for neutron science in the rest of the world. The most important of these are the reactor-based source at the Institut Laue Langevin Research Reactor at Grenoble, in France; and the ISIS Spallation Neutron Source at the Rutherford Appleton Laboratory in the U.K.

We were fortunate to have the Directors of all the major U.S. facilities present at our meeting, and they helped prepare a statement describing the instrumentation at HFBR and the relative contributions made to neutron science in the U.S.

Without going into details, neutron scattering is a major area for research. The major tools and techniques are: Triple Axis Spectrometers; Small Angle Neutron Scattering; Powder Diffraction; Reflectometry; and Single Crystal Diffraction.

The Triple Axis Spectrometer is essential for the fundamental understanding of new materials, and the HFBR instruments are particularly well-suited to the study of very weak signals because of the unique construction of the reactor itself. As a result, the HFBR spectrometers are recognized as a world-leading capability. They represent 43% of the U.S. capacity.

Small Angle Neutron Scattering (SANS) is regarded as a particularly useful technique by structural biologists, who represent a rapidly growing user community for neutron scattering. The HFBR SANS offers unique capabilities for the study of biological samples, and is the strongest in the U.S. in this area. It represents 21% of the U.S. capacity.

Single Crystal Neutron Diffraction complements x-ray techniques in determining the structure of complex organic molecules because of its ability to locate hydrogen atoms. HFBR represents 50% of U.S. capability.

The HFBR SANS is a unique capability, and if the reactor were to be shut down, this would disappear. The same is true of certain high resolution crystallography studies. In the case of the other scattering techniques, current HFBR users could apply for time at other U.S. facilities, but these are already considerably oversubscribed. The effect would be most harmful in the case of triple axis spectrometry, because of the large fraction of the instruments which are at the HFBR.

Finally, BESAC heard many examples of the important scientific advances that have been made as a result of neutron science, and significant contributions to the resolution of industrial problems, both in general and specifically at HFBR. We also heard about the growth of new user communities, in biology, in polymers, and in surface science and engineering. The value of close interactions with the cyclotron light sources was also described.

On the basis of this, it is clear that the importance of neutron science has not diminished since the Kohn report, but has expanded; and in particular, techniques using cold neutrons have become more and more important to the newer user communities. The major source of cold neutrons in the U.S. at the moment is NBSR, but HFBR has the capability to greatly increase the availability of cold neutrons. As the Birgeneau report of 1996 said, "the gap between U.S. and, especially, Western European capabilities in neutron science has grown dramatically since the Kohn Panel report. This is particularly true for the increasingly important area of cold neutron research where in Europe there are 6 cold neutron guide halls compared to 1 in the United States".

Answers to the Committee's Charge

(1) What are the impacts of the current shutdown of HFBR on United States neutron science research supported by Basic Energy Sciences, by other government funding agencies, and by industry?

The Table below shows the number of neutron scattering beam hours in HFBR's last full year of operation, divided into the technical areas described above.

Instrument	Beamline Hours	HFBR % of U.S. Capacity
Triple Axis	87,018	43
Small Angle Neutron Scattering	60,161	21
Powder Diffraction	63,994	20
Reflectometry	43,474	14
Single Crystal Diffraction	37,592	50

(Note: the percentage of capacity refers to all U.S. neutron sources, both reactor and spallation source instruments, except for triple axis instruments which only exist on reactor sources).

From this it is clear that the current shutdown is having a profound impact on investigators using neutron scattering methods in their research. The Committee received approximately thirty letters from senior researchers calling for a prompt restart of the HFBR, and we listened to a presentation from the users' group detailing problems. There is no doubt that for a short time some flexibility exists using other U.S. facilities and international facilities such as ILL and ISIS. However, the oversubscription of all neutron scattering facilities world-wide means that within a relatively short period researchers will be compelled to switch to other fields, to the long-term detriment of this important area.

(2) To what extent can other neutron sources in the United States or elsewhere accommodate the scientific users displaced from the HFBR shutdown? Provide an analysis of the extent to which the completion of the upgrade to the Los Alamos Neutron Science Center short-pulse spallation source and the construction of the new cold source and cold guide hall at the High Flux Isotope Reactor will compensate for continual shutdown of the HFBR. Finally, what additional resources might be required at other Department of Energy neutron science facilities if HFBR were not to restart?

As indicated above, the researchers using techniques not unique to HFBR would be able to submit proposals to the other U.S. neutron source facilities, where they would compete on an equal basis with other users for available beam time. The net effect would be some reduction in the total amount of neutron scattering research done, and there would

certainly be no opportunity to foster the growth of the applications of the techniques into new areas. It was not possible to assess the access to sources outside the U.S., but several speakers pointed out to us that neutron scattering is very different from (for example) high-energy physics: instead of the research being wholly concerned with a specific facility, neutron scattering (for example) is a technique used as a part of a research program to characterize aspects of a problem on which other studies are being made: travel to a remote facility is difficult to justify in many cases. In this sense, the neutron beam is regarded as a user facility similar to a light source or an electron microscope.

Where the capability at HFBR is unique, as in SANS, or a significant world-leading technique, as in triple-axis spectrometry, accommodation by other facilities is not really possible: the quality of the results would not be acceptable.

The upgrade to the Los Alamos Neutron Science Center Spallation Source will provide more neutrons, but short-pulse spallation neutrons are not appropriate for all the same experiments as steady-state reactor neutrons. The Kohn Panel Report discusses the complementary nature of the two types of sources in some detail (pages 40 - 44). In our discussions, some estimations were made as to which HFBR users might be well served by the upgraded LANSCE, but this fell short of an analysis.

The provision of a cold-neutron guide hall at the HFIR as part of the upgrade is a welcome advance, particularly with regard to SANS. However, the capabilities will not replace all of the expected capacity of a cold hall at a 60 MW HFBR.

Overall, it is clear to us that major losses of capacity and quality would be an inevitable consequence of the shutdown of the HFBR.

We were unable to estimate what additional resources would be needed at other DOE neutron science facilities if HFBR were not to restart because there was not enough information available: the problem is in any case very complex. Should a decision be taken not to restart HFBR, we recommend that a detailed analysis of the implications for neutron science in the U.S. and the additional resources required by the other facilities be undertaken at that time.

(3) Several scenarios for the future of HFBR will be presented to you: among these will be (a) restart at 30 MW operation; (b) restart at 30 MW operation with a planned path to eventual 60 MW operation; or (c) shutdown. After consideration of all these scenarios, what would be the most appropriate course to pursue in the context of U.S. neutron science and in the context of United States neutron science and in the context of the entire portfolio of research supported by the Office of Basic Energy Sciences?

It is apparent from the discussion above that the Committee as a whole supported the view which had emerged from the earlier ad hoc committee, which rejected alternatives (a) and (c). This based in part upon the assurance that the impact on OBES's budget would be essentially zero. This recalls the earlier recommendation of BESAC contained

in Carl Lineberger's letter to you of March 10th, 1996, which said "While the proposed upgrades are critically important to the future of neutron scattering science in the United States, the Office of Basic Energy Sciences faces severe budget restrictions, and the proposed upgrades and construction projects must not come at the expense of the other research activities of OBES". Obviously, any slip in the timing of the project would have an adverse effect on the budget, and care must be taken to maintain the Department's good record for completing projects like this on time and under budget.

Recommendations

(1) The Committee strongly recommends that the High Flux Beam Reactor at Brookhaven National Laboratory be restarted as soon as possible, to minimize the effect on neutron science research in the United States. It should restart at 30 MW, and move to 60 MW in a timely manner. All the actions required for this move to 60 MW should be completed before start-up: if the start-up were to be at 30 MW with no clear plan to move to 60 MW, it **should not be done**.

The Birgeneau Subcommittee had earlier recommended a resumption of operation at 60MW. In making our present recommendation, we are not suggesting that the more extensive upgrade also proposed by the Birgeneau Subcommittee be undertaken at this time; this is an action for the future. The objective is to restore the operation to a level which it had operated at before, and which the advice presented to us showed was acceptable from all points of view. The effect will be to increase the supply of neutrons to researchers, without requiring unreasonable delays and expenditures at this time.

Resumption of operation at 30MW without the intention to move expeditiously to the higher power will not, in our opinion, provide a facility that warrants the expenditure of the funds that will be required for the restart.

(2) It is very important that the path to restart should be as expeditious as possible, to aim at a start in 1999.

(3) The Department should proceed as soon as possible with a full Environmental Impact Statement. We believe that the issue of whether this is formally required or not is irrelevant: reassuring the local community that all care is being taken is of paramount importance. We were assured that new procedures mean that the EIS can be completed in 15 months, and it is important that all steps are taken to ensure that that timetable is adhered to.

(4) All work that will be required whatever the outcome of the EIS should be undertaken immediately. These include the installation of a liner in the fuel pool; the installation of double-wall piping; the modification of the exhaust stack drain piping; and resealing floor joints and penetrations. In addition, planning for the seismic upgrades should be completed while the EIS is in progress; and OBES should explore what actions on implementing the upgrades prior to the completion

of the EIS are permissible. The objective of this is to shorten the path following the Record of Decision.

(5) The leadership in neutron science which the U.S. once enjoyed has been lost, and will be difficult to recover, mostly as a result of the cancellation of the Advanced Neutron Source. The recommendation to construct the National Spallation Neutron Source, together with the upgrades to HFBR, HFIR, and LANSCE, represents earlier efforts by DOE/OBES, with help from the Basic Energy Sciences Advisory Committee and its Panels, to recover our significant place in the important field of neutron research. The loss of any one of these components is a major issue, because there is now no margin; and we request that, should a decision be taken not to restart HFBR under the conditions outlined above, we have the opportunity to review the implications for the whole field of neutron-based research in the United States once again.

With best wishes,

John Stringer, Chair, Basic Energy Sciences Advisory Committee
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